ACTIVE HOUSE - the guidelines

Comfort
Energy
Environment

Editorial

The purpose of the guideline is to guide architects, engineers, investors and others who are in a process of designing an Active House. It is the intention that the guideline will be used in the very early design process as a tool that can prepare the project for a later Active House evaluation based on the Specifications.

The guidelines introduce the three main criteria and the sub criteria from the Active House Specifications. They give recommendations on topics that should be evaluated in the early design stages and can be used as a dialog tool between the designers themselves and between the designers and the specific house owners.

The specific calculation of an Active House and the performance of an Active House can be made by following the Active House specifications (download from www.activehouse.info) as well as the Active House Calculation tool (download a 30 days trial version at www.activehouse.info)

This version has been made by members of the Active House Alliance and several workshops have taken place in the process. We would like to thank all for their contribution with these guidelines, which are the first version and which will be updated again in spring 2016. Comments and input are welcome and can be send to guidelines@activehouse.info

On behalf of the Active House Alliance

Kurt Emil Eriksen
Bruxelles
March 5th 2015

Members Of the Active House Alliance March 2015:

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Active House - a vision of buildings that

Vision
Active House is a vision of buildings that creates healthy and comfortable lives for their occupants without negatively influencing the climate and environment – moving us towards a cleaner, healthier and safer world.

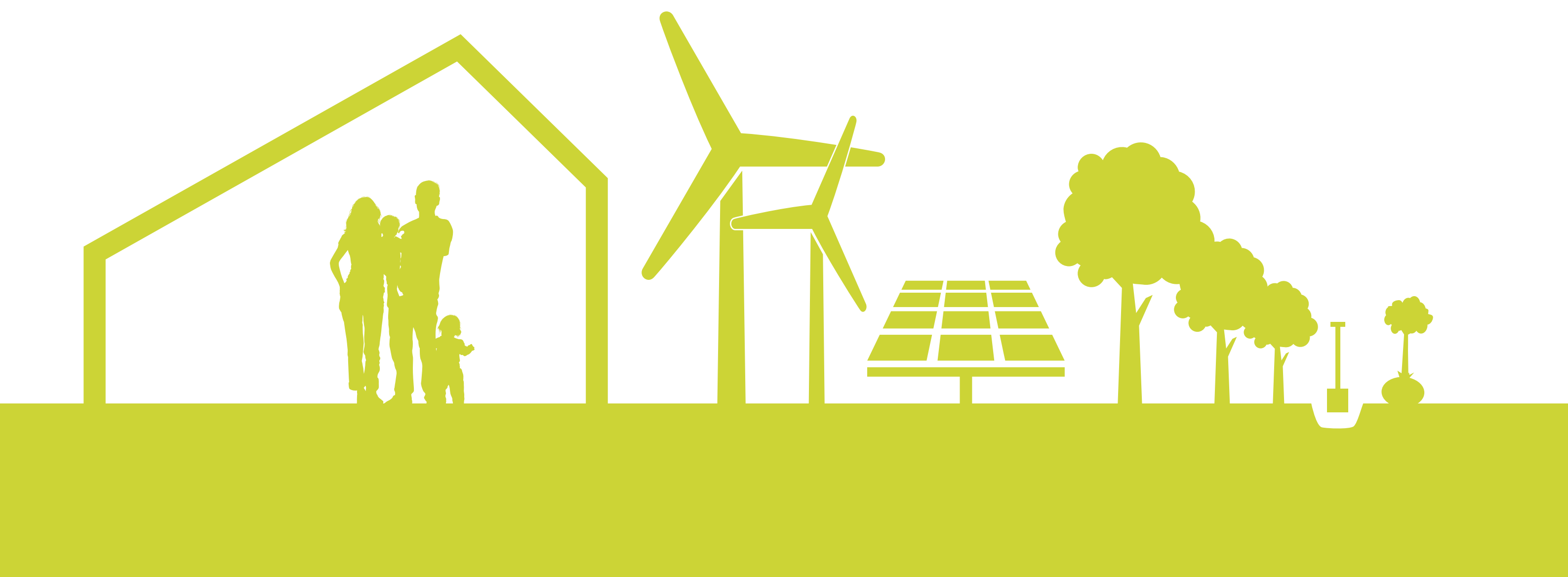
Active House proposes a target framework for how to design and renovate buildings that contribute positively to human health, safety and wellbeing by focusing on the indoor and outdoor environment and efficient use of energy.

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

Indoor Climate - Creates a healthy and comfortable life
An Active House creates healthy and 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 highly energy efficient. All or most of the 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 neutral impact on the environment
An Active House interacts with the environment through an optimised relationship with the local context, focused use of resources, and its overall environmental impact throughout its life cycle.



give more than they take

Affordable
Sustainable buildings should be designed with an overall focus on affordability. The Active House vision and the developed tools offer opportunities for a balanced design with focus on affordability and cost efficiency across different topics, technologies and solutions.

The designers can reduce the costs for projects by defining the requirement and ambition of the performance levels in the very early design process. By doing so the balance between the requirement and overall costs can be identified and discussed, as well as it will reduce the risk of unexpected costs in a later stage of the design process.

Monitoring
The ambition and the performance of an Active House is based on calculation, including pre-defined values and expectations of user behaviour. In order to secure that the final project meets the expected levels and ambitions, it is strongly recommended to include monitoring of the project. Such monitoring should take place during one year as minimum and the differences between the calculated performance and the specific performance can be described in the Active House Radar and calculation tool. It is recommended to follow up and adjust where needed.

Specification and calculation tool
The Active House Specifications describe the main parameters to be evaluated for an Active House and set the specific levels needed to reach different levels of Active House.

The Active House calculation tools, radar and classification are used to describe and communicate the performance of specific projects. It includes a possibility to calculate the specific project and to create a reference radar, which can be the national legislative requirement, a reference from other projects or the monitored values.

These guidelines give examples of best practice on how to build an Active House and how to take the main issues into consideration earlier in the design phase.

General introduction to the Guidelines

Introduction
These guidelines are intended to be an inspiration and a supporting document to the Active House Specifications for designing an Active House.

They are intended to be used in the conceptual design stage of an Active House and focus on the three main criteria Comfort, Energy and Environment. They take into consideration topics that should be considered in the very early design phase of an Active House and discuss key principles that influence the evaluation of the Active House concept. They create the platform for a later evaluation of a built Active House, based on the Active House Specifications and the Active House Radar.

The guidelines are divided into four chapters, giving recommendations on how to efficiently address the three performance criteria (Comfort, Energy and Environment), as well as on the use of the Active House Radar. The individual chapters include tips and rules of thumb for the conceptual design, describing also factors that may influence the optimum level of performance for all criteria.

Quantitative and Qualitative criteria
The guidelines focus on the quantitative and qualitative parameters laid down in the Active House Specifications.

The quantitative parameters described in the Active House Specifications represent the nine most important topics for an Active House evaluation. Each parameter is evaluated individually and used in the Active House Radar diagram and the classification. Therefore, the guidelines mainly focus on these nine quantitative parameters, suggesting/offering solutions to create a good Active House performance and a high score for each of them.

The qualitative parameters described in the Active House Specification represent additional concerns that should be included in the global assessment of performance for an Active House.

QUANTITATIVE CRITERIA

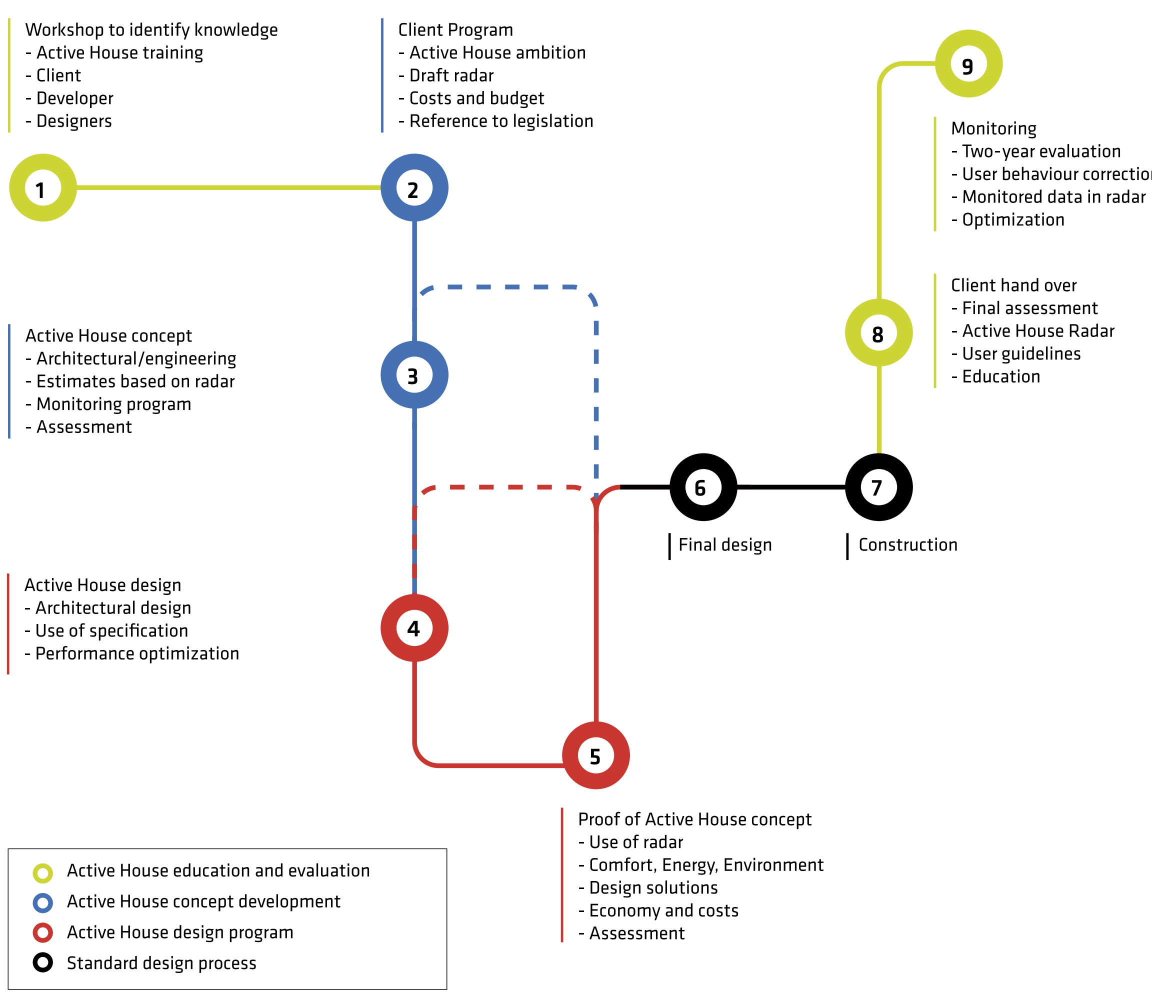
COMFORT
1.1 Daylight
1.2 Thermal Comfort
1.3 Air Quality

ENERGY
2.1 Energy Demand
2.2 Renewable energy
2.3 Primary Energy

ENVIRONMENT
3.1 Environmental Load
3.2 Water consumption
3.3 Sustainable construction

Active House Radar
The evaluation of an Active House is based on the nine quantitative parameters mentioned, each split into four levels of performance (1 through 4), where 1 represents the highest performance. Each parameter is calculated in accordance with the Active House Specifications, with these guidelines offering conceptual orientation/help on how to reach the high or highest performance level.

RECOMMENDED STEPS FOR ACTIVE HOUSE PLANNING



Comfort

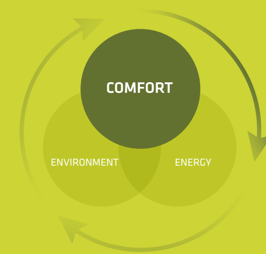
People living in modern societies spend the most part of their time indoors, at home, at their work place, or during leisure activities. Thanks to modern technologies, we can do what we want when we want, but what is the impact on our wellbeing?

With the Active House specifications we want to promote solutions for people to live in comfortable buildings designed for human needs. After all, it is important not to forget that the primary function of buildings is to provide safe and enjoyable living environments for its inhabitants, aspects that should never be compromised.

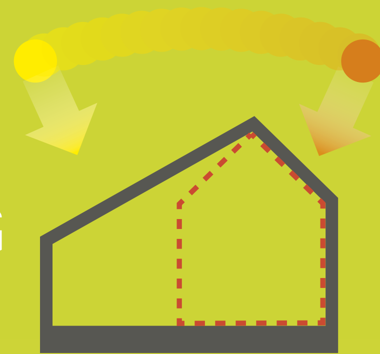
Daylight conditions are an important aspect of comfort in an Active House and can have a strong impact on our wellbeing. Findings in the field of lighting research have revealed that the quantity and quality of light received by our eyes not only affect our vision, but influence an array of non-visual effects including sleep and wake cycles, mood, productivity and alertness among others, and most importantly our long-term health.

Thermal comfort plays a vital part in achieving healthy indoor environments. An Active House should be designed to provide optimal thermal comfort both during the winter and summer periods. The human capacity to adapt to different temperatures, as well as our needs for temperature variation through the course of the day and different rooms of the house should be taken into consideration. Thermal comfort in an Active House is evaluated based on operative temperature.

In addition to daylight and thermal comfort, indoor air quality is another crucial factor in achieving healthy indoor environments. The amount of air humans breathe per day reach 15 kg, and as we spend up to 90% of our time indoors, it is indoor air we breathe. Active House reflects those needs by setting ambitious requirement to the indoor air quality.

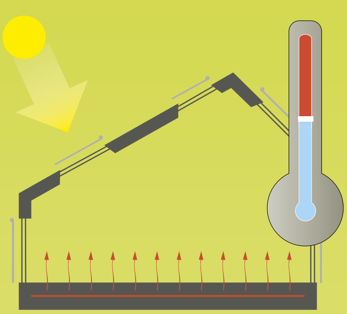


AN ACTIVE HOUSE OFFERS EXCELLENT INDOOR COMFORT TO PEOPLE LIVING, WORKING AND PLAYING IN BUILDINGS.

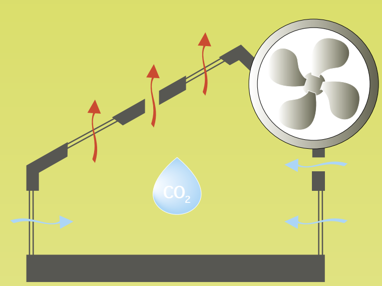


For comfort purposes, the shape and orientation of an Active House is optimised to the external climate. Solutions always depend on outdoor climate, hot or cold.

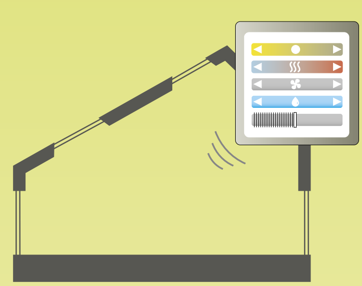
Daylight play an important role to people's health. An Active House is designed to deliver optimal daylight in primary rooms.



Thermal comfort plays a vital part in achieving comfortable living conditions. An Active House is designed to provide optimal thermal comfort both during the winter and summer periods.



The amount of air humans breathe per day reaches 15 kg, and as we spend up to 90% of our time indoors, it is indoor air we breathe. Active house reflects those needs by setting ambitions requirements to the indoor air quality.



Intelligent systems are important in modern homes and help optimise the indoor climate. An Active House is optimised through intelligent control of the main comfort parameters.

PEOPLE LIVING IN MODERN SOCIETIES SPEND

90%

OF THEIR TIME INDOORS

DAYLIGHT

Daylight has been utilised as the primary source of light in buildings for centuries, but only recently have findings in lighting research revealed that the benefits associated with daylight go far beyond our needs for vision as daylight is a vital part of our psychological and physical health.

We evolved under the light from the sun, and our bodies are intrinsically linked to the daily cycles and variations found in the natural world surrounding us. Exposure to high levels of daylight during daytime and darkness at night time has a strong influence on the entrainment of the human circadian system, by the regulation of hormones affecting sleep/wake cycles, mood, productivity, alertness and general wellbeing.

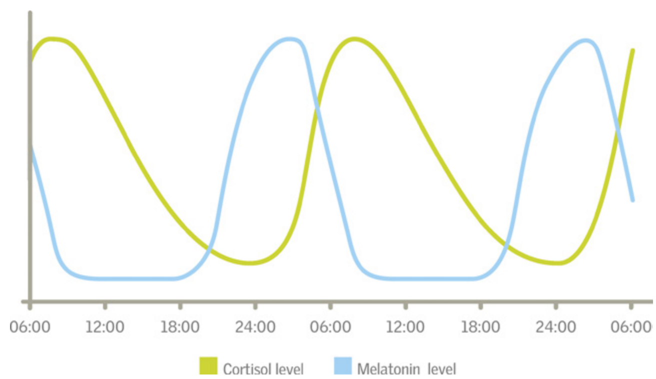
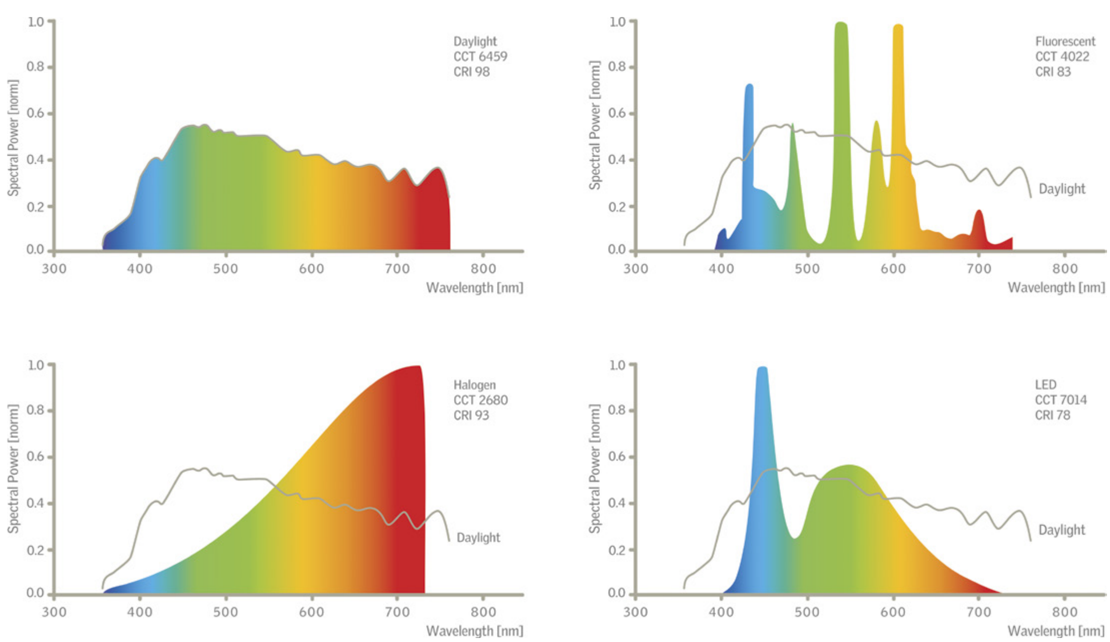


Figure 1: Production of the hormones melatonin and cortisol[1]

While it is true that some electric light sources can be constructed match a certain spectrum of daylight closely, none have been made that can mimic the spectral quality and natural variations that occur with daylight through the course of the day and seasons of the year. The figure below shows a comparison between the spectral compositions of typical light sources used in dwellings.

Figure 2: Spectral composition of four typical light sources used in dwellings, daylight (upper left), fluorescent (upper right), halogen (bottom left), LED (bottom right). Measurements provided by John Mardaljevic.



In addition to the quality of daylight as a light source, windows provide views to the outside environment and fulfill our needs to be in contact with nature, and to be informed about weather conditions, time of day, seasons and orientation. Studies have shown that people invariably prefer daylight as a light source, and a room with a view to the outside environment and nature. A view to nature can have a positive influence on someone's wellbeing, subjective health, environmental satisfaction, mood, sleep quality and more [4 5 6].

The daylight design of an Active House focuses on the importance of access to daylight, daylight qualities and view to the outside.

How to calculate daylight factor levels

Traditional requirements for daylight in residential buildings have been based on simple rules of thumbs such as glazing-to-floor ratio demand of 1:10. These requirements cannot ensure that daylight is either sufficient or correctly distributed in a room, and are therefore inadequate method to achieve high daylight quality in buildings.

Daylighting simulation tools, on the other hand, permit to evaluate both the quantity and distribution of daylight in a room, while taking into the key account influential parameters such as window placement, obstruction and glazing transmittance.

Daylight factor
Daylight conditions in Active House projects are evaluated using the daylight factor method in a validated daylighting simulation tool.

By definition, the daylight factor (DF) is the illuminance (E) on a surface expressed as a percentage of the external diffuse illuminance.

$$DF = \frac{E_{surface}}{E_{external}} \times 100\%$$

The average daylight factor levels should be determined for all the main living areas of the house including the kitchen, living room, dining room, children bedroom and playroom. Other areas of interests to consider in the design are the main circulation spaces, and bathroom(s) used during the morning period.

An average daylight factor of 5% (level 1 performance) will ensure that a room appear substantially daylit, whereas an average daylight factor of 2% (level 3 performance) will provide only a modest amount of daylight and electric lighting is likely to be frequently used.

Work plane – measurement area
Daylight factor levels should be calculated at a work plane height (e.g. 0.85m), and leaving a 0.5m border from the walls around the perimeter of the work plane, as shown in the example below.

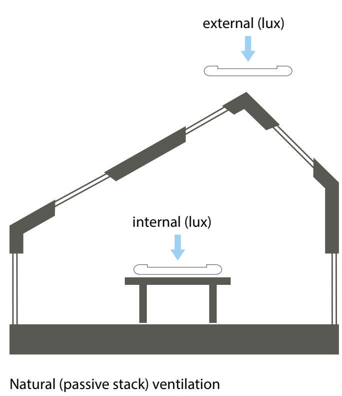


Figure 3: Diagram showing the measurement points of daylight factor calculations

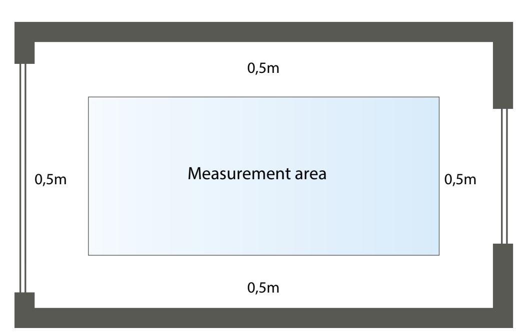


Figure 4: Diagram showing an example of the measurement area for daylight factor calculation, leaving a 0.5m perimeter around the room

Important - Factors affecting simulation accuracy
Daylight factor simulations allow to take into account the important factors affecting the availability and distribution of diffuse daylight in buildings. It is very important for users to have a good expertise of the simulation tool used in calculations, to know the limitations of the tools, and to correctly understand the situation they are trying to evaluate (building and its context).

Detailed window/room/building geometry
Simulation tools allow the use of 3D models in which the detailed geometries of windows, rooms and buildings can be taken into account. It is important to correctly account for all the design elements that will influence daylight availability such as framing elements, construction thicknesses, indoor divisions, as well as obstruction from external elements such as vegetation and neighboring buildings.

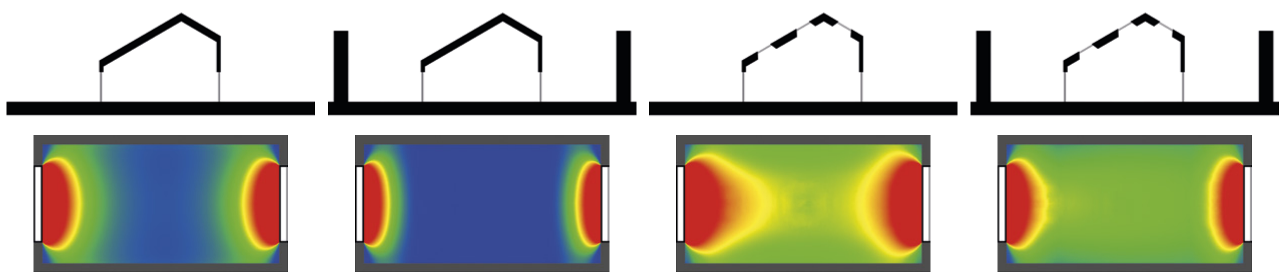


Figure 5 Example showing the effect of obstruction on daylight factor levels for a room with façade windows only, and a room with façade + roof windows.

Obstruction
Obstruction from landscape and nearby buildings that will influence daylight availability in the room need to be correctly accounted for in the calculations. Heavily obstructed windows will deliver significantly less daylight in a room than windows with clear view to the sky.

Glazing transmittance
The glazing transmittance has a direct impact on the amount of daylight that will be delivered from windows. It's important to use the light transmittance (LT%) value corresponding to the selected window products, and to correctly account for the framing elements and glazing bars, as well as the thickness of the building envelope.

Surface reflectance
The reflectance of surfaces inside and outside a room will influence the amount of daylight available and how bright a room will appear. It is therefore important to evaluate projects using realistic reflectance values based on real life material properties (e.g. a diffuse white paint can achieve a reflectance of approximately 0.8). The following values are recommended for use in simulations.

Table 1 Recommended reflectance values for use in calculations.

Surfaces	Reflectance values
Floor	0.3
Wall	0.5
Ceiling	0.7
Exterior groundvegetation	0.1 - 0.2
Exterior building	0.3 - 0.5

How to design optimally for daylight

Recommendations to optimise the quality and performance of daylight.
The building design should make sure to provide the following fundamental needs with regards to \daylighting:

- 24-hour cycle of illumination with period of darkness during nighttime, and bright light during daytime.
- Chance for exposure to bright levels of daylight (above 1000 lux) and sunlight during the winter period.
- View and contact to the outside world and nature.
- Avoid glare and visual discomfort.

Location & climate
In order to achieve a successful daylighting design it's important to understand the characteristics of daylight where the project is located.

- Latitude has a strong influence on solar elevation and daylight availability at different seasons of the year. High latitudes (closer to the poles) experience shorter periods of daylight during winter and longer periods during summer time, and have lower solar angles. Location with low latitudes experience smaller differences in the length of periods with daylight from winter to summer, and have higher solar angles.
- The prevailing climatic conditions of a building site define the overall preconditions for the daylighting design in terms of daylight and sunlight availability, visual comfort, thermal com fort and energy performance.

Window size & position

- The size and placement of windows have a direct impact on the amount and distribution of daylight in the rooms. Larger windows yield higher daylight factor levels, and higher windows permit to deliver daylight deeper into the rooms.
- Multiple windows with different orientations, and adequate positions, can provide a room with a more uniform distribution of daylight, and increase the area of the room where it can be used as an autonomous light source.
- Roof window and skylights can be used to deliver daylight and sunlight in the deeper areas of the room/building which cannot be reached by façade windows.
- Highly reflecting light tubes can be used to deliver sunlight and daylight into windowless spaces. Rigid light tubes perform better than flexible ones.

Window glazing
The type of window glass should be selected based on:

- Its energy balance and thermal performance; considering both solar gains (g-value) and heat loss (U-value). Low U-value combined with high g -value is recommended for cold climates, and medium U-value combined with low g-value is recommended for warm climates
- Its light transmittance properties (LT%); the higher the better.
- Its spectral transmittance properties; the more neutral the better to keep the quality of daylight and high color rendering index (CRI).
- Solar controlled glazing with dynamic g-value etc, can be used to optimise the performance, depending of the outdoor conditions.

View & contact to nature

- The building site should be carefully studied to identify the best possibilities for views and contact to the outdoor environment.
- The size and position of window systems need to be considered in relation to the eye level of building occupants in order to ensure adequate views to the outside.
- Views in a room should be designed to include layers of sky, urban/natural landscape, and ground.
- Windows with different orientations can be used to keep unobstructed views when shading is needed to control sunlight in some orientation.
- Allow distant views and minimize overshadowing.

Sunlight availability

- The main rooms of the house should have access to direct sunlight during the winter period to provide high levels of daylight to the occupants.
- The house design should allow for penetration of sunlight deep into the rooms, and across the rooms, during the winter period.

Shading & glare control

- Shading devices should be used to control visual comfort and privacy in rooms where it is needed.
- Black-out blinds or shutter should be used in bedrooms to provide darkness during sleeping hours.
- Glare from direct sunlight reflections and high luminous contrast between surfaces should be possible to avoid with shading devices controlling the amount of daylight entering the room.
- Direct sunlight reflections and high luminous contrast between surfaces may cause glare. Shading
- devices by controlling the amount of daylight entering the room solve the problem. Nevertheless, pay attention of the color of the shading especially for the fabric as clear color fabric might also
- become a source of glare.
- Highly reflective materials inside or outside the building can become sources of glare when exposed to direct sunlight and within the field of view of the occupants.

Thermal environment

Thermal environment is a very important part of comfort in buildings. Comfort is a state of mind. Health is a state of body and mind. Both, per definition, it cannot be controlled by technical control systems. Building automation can only keep relevant parameters in those ranges, which are supposed to not more than offer the chance for feeling comfortable or living healthy.

Keeping comfortable levels of temperature is not only important for our comfort but it can also prevent and alleviate illnesses.

Ideal thermal comfort is not a fixed set of temperature limits valid for all people. We all have our own preferences for temperature and may in fact desire variations in our thermal environment to counteract "thermal boredom" [8 9]. Furthermore, we adapt to the thermal environment via adjusting our clothes, by moving away from direct sun or other heat sources such as a fire place, or by other means. Psychologically we also adapt our preferences. A winter day with a temperature of 25°C might therefore be too warm whereas it is experienced as pleasant on a summer day.

Thermal discomfort is not only the air being too cold or warm but can also be caused by difference in temperature, e.g. cold draught from a window or being close to a cold surface. Asymmetry in temperature can cause discomfort, e.g. sitting next to a large windowpane on a cold winter night can be uncomfortable even though the air temperature is at an adequate level. Securing a high surface temperature on the inside of the building envelope will also increase/maximise the useful m^2 of the building.

The Active House Specifications use use the adaptive approach to evaluate the thermal environment. The idea behind the method is that people adapt to the outdoor temperature as it rises and falls. We adapt psychologically but also by adjusting our activity, clothing level or by opening or closing windows. The adaptive method uses the outdoor running mean temperature (T_{rm}) to vary the comfort limits. The running mean temperature is a weighted average where the temperature from the previous day has the biggest impact, the temperature from two days ago has a smaller influence, and so on.

Thermal comfort is essentially to consider as an overall sensation of the remaining influences for human beings in the indoor environment. Thermal properties cannot be regarded as separate comfort factors, rather they are determined by the visual, acoustic, olfactory and radiation conditions as well as by the subjective general and actual psycho-physiological characteristic state of a particular person. This overall sensation effect defines and generates also people's thermal comfort level. Thermal perception is influenced by the following thermal impact factors and their interdependency[10].

Active Houses minimise overheating in summer and optimise indoor temperatures in winter without wasting energy.

Operative temperature

People's perception of a comfortable climate is dependent on more factors than air temperature alone. The operative temperature is an attempt of providing the temperature actually experienced indoors by people[a]. In general terms, the operative temperature is a combination of the air temperature and the surface temperatures.

The operative temperature is often calculated as a weighted average of the two above mentioned temperatures, which are dependent on the velocity of the air.

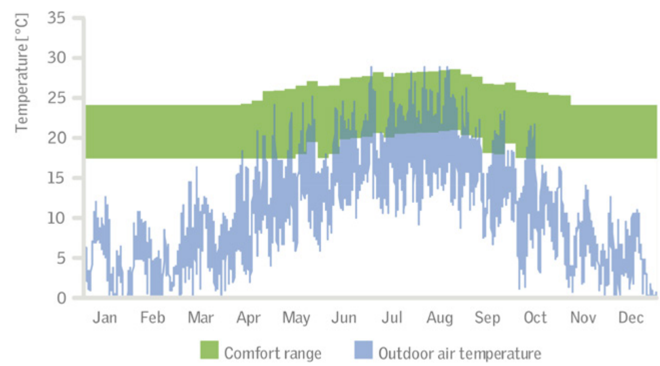


Figure 6: Perceived comfortable indoor temperature range for the adaptive method, dependent on the outdoor temperature

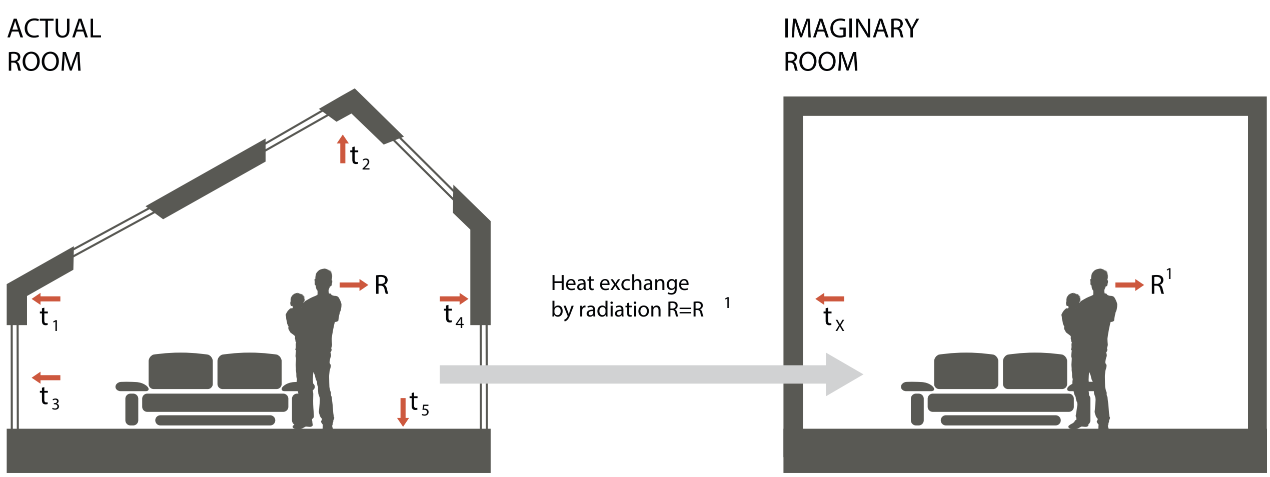


Figure 7: the operative temperature in the simplified room should be comparable to a real life situation

Operative temperature can be used to evaluate thermal comfort in a building. This temperature is often a part of the result from a detailed energy simulation performed to check the energy demand of the building. Use of energy to maintain a nice thermal environment is also one of the main contributors to the total energy demand. Many validated computer programmes are available to evaluate both energy and thermal comfort and take into account most of the influencing factors. Monitoring feedback is therefore necessary for the building owner to be able to assess the actual performance of the building, as simulation software only has a limited accuracy compared to real measurements.

The Active House specifications use the operative temperature to evaluate thermal comfort. It should be calculated for main living areas like kitchen, living room, dining room, children's room, bedrooms etc.

[a] It is defined in the international standard "ISO 7730 Ergonomics of the thermal environment" as: "Uniform temperature of an imaginary black enclosure in which an occupant would exchange the same amount of radiation and convection as in the actual non-uniform environment".

Important factors affecting operative temperature

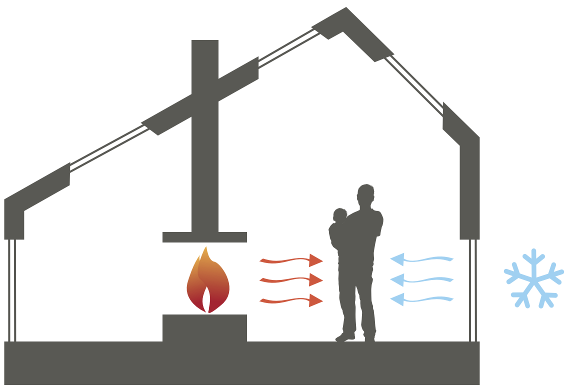


Figure 8: person exposed to one cold and one warm surface

The operative temperature is the result of the indoor air temperature and the average temperature of the room defining surfaces.

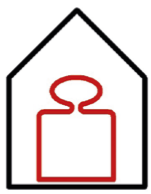
The air temperature is influenced by heat gains (solar gains, lightning, electronic equipment, people, etc.) and heat losses (through the envelope, draught, ventilation).

Draught can be caused by leaky windows, doors, or constructions. This is mainly a problem in old buildings. Large cold surfaces caused by bad insulation (both walls and windows) can also create a draught by downward convective currents due to cold inside surfaces associated. In this case, replacing the window/pane with better performing ones or placing a heating element below the window can be a solution. Be aware that placing a heat source under windows (with old panes) cause unexpected transmission heat loss and that if a lack of insulation is the main problem, it should be investigated if proper insulation can be installed before installing additional heating.

The radiant temperature is a weighted temperature of all the surfaces temperatures depending on your position in a room. The way you feel the several surface temperatures depends of the view factor (distance from the surfaces, size of a surfaces). Well-insulated constructions are able to keep the surface temperature close to the air temperature whereas poorly insulated constructions will result in low surface temperatures. Warm surrounding surfaces ensure no constant radiation exchange and a low air temperature is not perceived as unpleasant. This is the case when e.g. the surface temperature with normal clothing is 21 °C and the wall temperature is 22 °C and the air temperature is 17 °C .

How to design optimally for thermal environment

The thermal capacity of the structure

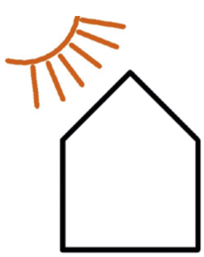


The thermal mass of the constructions can be used to dampen the temperature variations. In warm climates a high thermal mass can be cooled down during night through passive ventilation to ensure cooler temperatures for a prolonged period during the day. Thermal mass also enables high-level thermal comfort in summer due to long periods of cool surfaces and in winter through warm enclosing surface temperatures in a room. Take into account the thermal behaviour of each room to optimise the design of the building depending on the orientation and the use of each room. Thermal mass can be used as part of energy efficient thermo activated slab and wall structures through radiant heating or cooling.

Humidity in the air and in surfaces

The thermal comfort perception is highly influenced by the moisture content of the air. Relative humidity strongly influences the thermal comfort sensation, whereby in higher relative humidity conditions normal temperatures are disagreeable, e.g. at 95% relative humidity 25 °C is already uncomfortable muggy warm. Wet indoor building surfaces are able to cool the interior in hot and dry climate zones in combination with natural cross ventilation, respectively stack affect and wind driven passive ventilation. In e.g. northern and central Europe, humidification and dehumidification is normally not necessary in residential buildings.

Solar Radiation effect

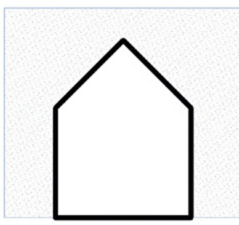


Direct solar radiation produces pleasant warming effect directly on human skin. Direct radiation creates warm air and surfaces in glasshouses in winter, but mainly in transition periods, which can reduce the heating demand considerably.
In buildings with large windows, measures must be taken to prevent overheating. Recent residential demonstration buildings show that high daylight levels can be achieved without overheating, when Solar Control glazing or dynamic external solar shading are used in combination with natural ventilation (ventilative cooling). Orientation greatly influences the solar load of interiors, e.g. in a fully glazed office building, east oriented rooms preserve 65% more solar load in comparison to south facing rooms. This is 100% higher in west oriented rooms in the same example building.

Building envelope quality and flexibility

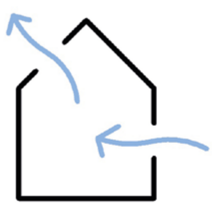
Orientation of facades and designed functions, as well as outer climate impacts and geographical position strongly determine the solution of building envelopes. Consider the layout and orientation of the rooms based on their function. Rooms with a need for cooler temperatures, like bedrooms, can be placed on the north to reduce solar gains. Fixed external solar shading (e.g. awnings) can be used on the south façade to control overheating in summer but still provide an outdoor view and daylight. Well-insulated walls, roof and basement with high thermal mass on the inside are basic requirements of efficient and comfortable building envelopes.

Design glazing types according to orientation, summer or winter thermal design strategies. Moveable external shading can enhance the performance of windows to ensure comfort and low energy consumption. Give users the ability to adjust the façade and roof structures (open windows, operate shading) to deliver high individual comfort level and low HVAC and energy demand to run the building.



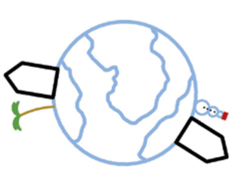
Thermal buffer zones

Allow different tempered rooms, e.g. a winter garden or an entrance where you can enter, get packed, dressed etc., without draining the rest of the house of thermal comfort. Thermal buffer zones exhibit two essential functions: thermal protection against winter heat losses (in sunny days also heating energy gains) and extended functional spaces to use. In alternating seasonal periods buffer spaces are differently in use. They can serve as an extended living room in transition and winter seasons, as a thermal air collector they ensure further heating energy support.
In summer time winter gardens get high inner temperatures and dampen heat impact through the building envelope, therefore in these seasonal periods they are not occupied. Night passive ventilation cooling can compensate daily overheating of these zones. Thermal buffer zones possess complex and adaptive building envelope space-like structures to regulate buildings comfort and energy balance.



User sensorics and ventilation

Fresh air sensation is an important comfort parameter. The sensation of light air movement causes comfortable cooling sensation in summer period, while in wintertime lower air velocities are indispensable to avoid thermal discomfort. While in heating periods mechanical ventilation is a very economic and energy efficient method to create confortable air supply (air change) in interiors due to high performance heat exchangers, in transition periods window ventilation ensures appropriate airflow rate. In cooling periods natural ventilation cools the interior via night ventilation cooling. Even in hot summer periods well-dimensioned natural ventilation (moving air streams) creates a pleasant cooling, refreshing feeling.



Outdoor environment impact

A view to the outside, connection to the surroundings is a basic human need in almost all interiors. The outdoor climate plays a role on different levels. The geographical location determines the yearly and seasonal rhythm of the indoor climate. The local settings (rural, urban) influence the given climatic circumstances, while the local microclimate has a great impact on the particular building site and its thermal properties. Aspects such as shape of the building, orientation, materialisation, building services and energy systems and - as a result - the indoor thermal comfort is determined by changeable environmental factors such as wind direction and speed, solar radiation, humidity and temperature.

Indoor air quality

The indoor air quality in buildings has to be focused on from a health and comfort perspective. Adults consume two to three litres of liquids and one to two kilograms of food per day. While hygiene and safety of what we eat receive great attention, air quality gets very little even though on average we inhale 15 kg of air per day—90% of which indoors.

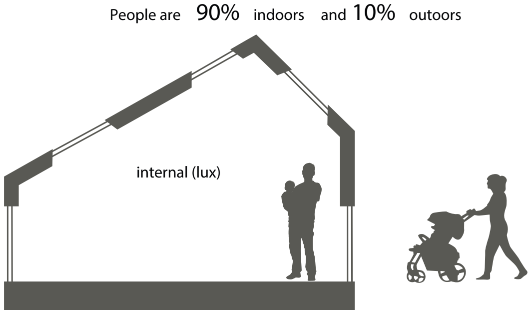


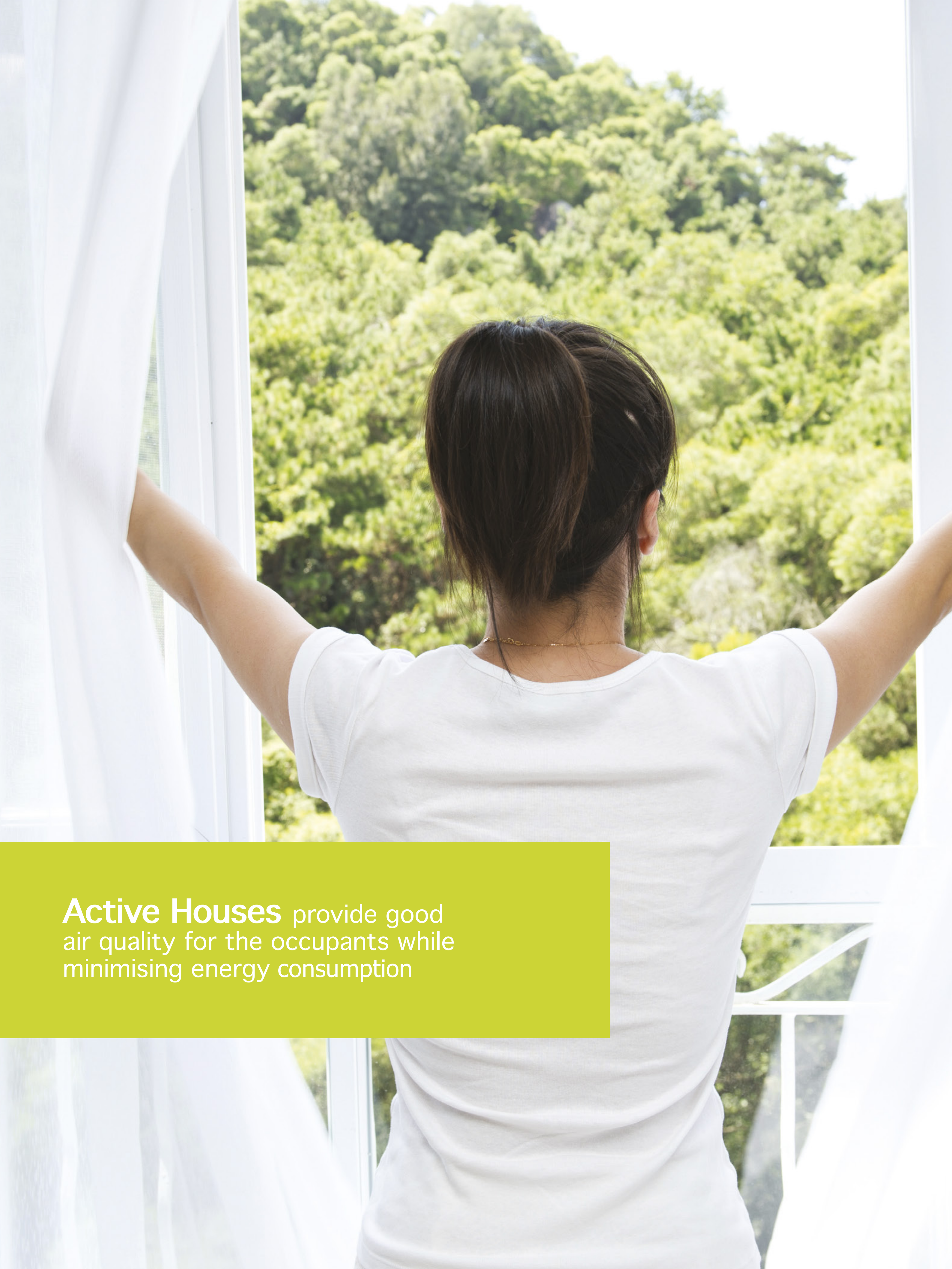
Figure 9: Time typically spent indoors and outdoors

We tend to think of air pollution as something outside: smog, ozone, or haze hanging in the air, especially in summer. But, the truth is that the air inside homes, offices, and other buildings in most cases is more polluted than the air outside. Some pollutants arrive via a new mattress or furniture, carpet cleaners, or a coat of paint on the walls. Children, people with asthma or other illnesses, and the elderly may be especially sensitive to indoor pollutants, but other effects on health may appear years later, after repeated exposure.

In recognition of this, many national labels for building materials with minimal indoor environmental impact have been created, such as the Finnish M1, the Danish indoor climate label and the German AgBB and GUT labels. By prioritising building materials and furniture with one of these labels, the risk of excess levels of indoor pollutants emitted from materials is minimised.

- Carbon dioxide (CO_2) is not a pollutant by itself, but may be a useful indirect indicator of the level of indoor pollutants that are generated by human presence and human activities. CO_2 concentration is expressed in ppm, with preferred levels stated in the Active House Specifications.
- An additional cause of indoor climate related illnesses is humidity, added to the indoor air from daily activities and outdoor air in summer. Humidity can become problematic if the levels are too high or too low, which is a problem in many buildings.
- Radon is emitted from the ground beneath the building, and the exposure depends on the local geology around the house. Most countries have regulations on how to seal the house to minimise radon penetration, and these regulations are important to follow.

Ventilation is necessary to provide a healthy and comfortable indoor environment for the building's occupants. The main task of ventilation is to remove polluted indoor air from a building and replace it with 'fresh' (outside) air. Ventilation can also serve other roles – for instance, to provide an air supply to open-flue combustion appliances and to form part of an integrated strategy to provide thermal comfort and control summertime overheating. The requirements for good indoor air quality and energy efficiency have often been considered to conflict with each other. Good indoor air quality requires ventilation with fresh outdoor air. In the cold season this air needs to be heated up to maintain good thermal comfort. The challenge is to find the right balance of ventilation and energy consumption in such a way that you have a good indoor climate with as low energy demand as possible , for example by recovering heat/cold from the exhausted air during winter/summer.



Active Houses provide good air quality for the occupants while minimising energy consumption

Impacts on air quality

In the past, the 'draughtiness', or lack of air tightness, of building envelopes would provide a constant flow of air through the building, but also allowed uncontrolled ventilation heat loss.
A common problem today, especially in new constructions, is that buildings are tightly sealed to preserve thermal energy inside. This causes a lack of natural airflow, so fresh air cannot make its way inside. In addition indoor air cannot circulate and becomes stale and stagnant. This means that all of the contaminants floating around indoors have no way to escape, in case no adequate ventilation strategy is present.

There are different types and sources of pollution within the home, for example:

- Moisture, e.g. from washing, cooking
- Carbon monoxide (CO) and oxides of nitrogen, e.g. from combustion alliances, smoking
- Volatile organic compounds (VOCs), e.g. from aerosols and formaldehyde in furniture
- Allergens, e.g. from house dust mites.
- Carbon dioxide (CO_2), e.g. from humans and indoor combustion processes
- Environmental tobacco smoke (ETS).
- Odours, e.g. from cooking, bodies and pets.

Although CO_2 is considered as non-toxic, very high levels can cause health problems to the occupants as its high concentration indicates low oxygen levels. Such high levels are typically not seen in residential buildings. From an indoor air quality standpoint, CO_2 is a surrogate for indoor pollutants emitted by humans and correlates with human metabolic activity. CO_2 at levels that are unusually high indoors may cause occupants to grow drowsy, get headaches, or function at lower activity levels due to the associated low oxygen level..
Humans are the main indoor source of CO_2. Indoor levels are an indicator of the adequacy of outdoor air ventilation relative to indoor occupant density and metabolic activity. Typically, the highest CO_2 levels are measured in bedrooms. So interior CO_2levels are a useful way to measure how efficient the ventilation system is at maintaining the ventilation rate required to refresh the air.

Moisture is probably the most significant of these because of the large quantities generated by activities such as cooking and bathing, and because of the associated problems of house dust mites and consequences of condensation such as mould growth. Research has shown, that if relative humidity levels exceed 70% for prolonged periods, there is a high probability that the condensation occurring on cold surfaces will lead to mould growth. Although research is still on-going on the most effective strategies to control house dust mites and allergen production, again the reduction of indoor humidity levels is a key factor. House dust mites are a known cause of allergy, to maintain the population at an unproblematic level, the relative humidity should be maintained at about 45% for a longer period. This is typically done during the cold winter months, when the outdoor air is dry.

Ventilation strategies

The need of ventilation and access for fresh air differ during the year, the day and within the individual rooms, leading to a need for a ventilation strategy that meet the individual purposes of the building and the users. As an example, the ventilation during winter will often be based on a need for moisture reduction in addition to removing air pollutants, whereas during the summer it often can have the purpose of cooling the building, in addition to removing air pollutants.

Ventilation strategies can be categorised based on their ventilation strategy.
Basically, the following cascade can be made to distinguish the different strategies:

- Single technology systems
    - o All natural
    - o Mechanical – extraction only or balanced ventilation
- Multiple, or hybrid technology systems
- Ventilative cooling

In general, mechanical ventilation systems require maintenance, as fans will need to be serviced regularly and filters and grills will need to be replaced or cleaned. Care should be taken to design the system in such way, that problems with noise are prevented.

Demand Controlled Ventilation
All ventilation strategies can be fitted with demand control. In a Demand Controlled Ventilation (DCV) system the ventilation airflow rate is continuously matched with the actual demand. By this, the DCV system offers an obvious advantage compared to conventional Constant Air Volume flow (CAV) systems. Demand control ventilation is recognised as being a method of ensuring a building is ventilated cost effectively while maximising indoor air quality.

Indoor Air Quality sensors (CO_2/VOC/Humidity) are used to continuously measure and monitor ambient conditions in the house and provide real time feed back to the zone controller which adjusts the window opening or ventilation rate to match the specific use and occupancy of the building.

Temperature sensors are used to determine the need for ventilation. Often the required airflow rate to prevent overheating is much higher than the airflow rate needed to maintain an acceptable indoor air quality.

For mechanical ventilation, the decreased average airflow rates means that less energy is needed for fan operation and for heating and cooling of the supply air. This advantage in terms of energy savings is often overlooked.

For natural ventilation, there is little heat loss when the outdoor temperature is above 12-14°C. Further, as ventilation is energy neutral during the warm periods of the year, high air flow rates and low indoor pollutant levels can be achieved without use of electricity or heating.

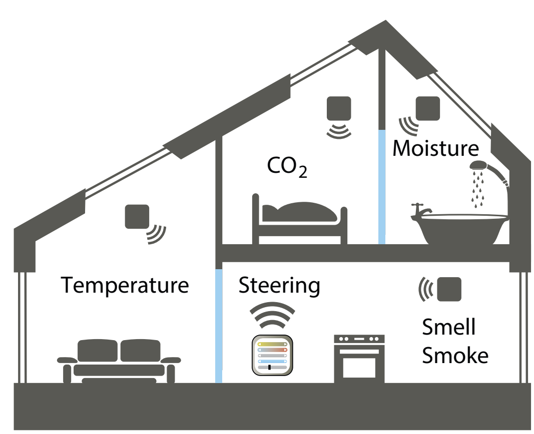


Figure 10: Principle for demand controlled ventilation

Natural (passive stack) ventilation
All natural ventilation systems comprise of inlets of fresh air in the façade and extraction via grills in 'wet' rooms (toilets, kitchen, bathroom) connected via near-vertical ducts to ridge or other roof terminals. Warm, moist air is drawn up the ducts by a combination of the stack effect and wind effect. The inlets can be automated grills based on wind pressure or CO_2 level, operable windows or air leakage (especially in older buildings). Providing a gap at the bottom of the internal doors will allow the free passage of air through the property. Pure natural ventilation is more difficult to control than mechanical alternatives.

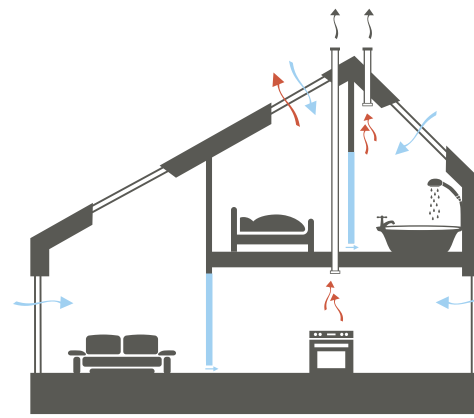


Figure 11: natural (passive stack) ventilation

Under normal circumstances, a natural ventilation system requires very little maintenance. Since no fans are used, it can be very energy efficient. However, in the cold season, the unheated outdoor ventilation air can cause an increase in heating demand.

Mechanical extract ventilation
A mechanical extract ventilation (MEV) system continually extracts air from 'wet' rooms. It usually consists of a central ventilation unit positioned in a cupboard or loft space ducted throughout the dwelling to extract air from the wet rooms Replacement air is drawn into the property via windows or background ventilators (e.g. trickle ventilators) located in the habitable rooms. Providing a gap at the bottom of the internal doors will allow the free passage of air through the property.

Mechanical extract ventilation can be coupled with demand control and/or a heat pump to recover thermal energy from the stale air and convert it to hot water for domestic use or heating.

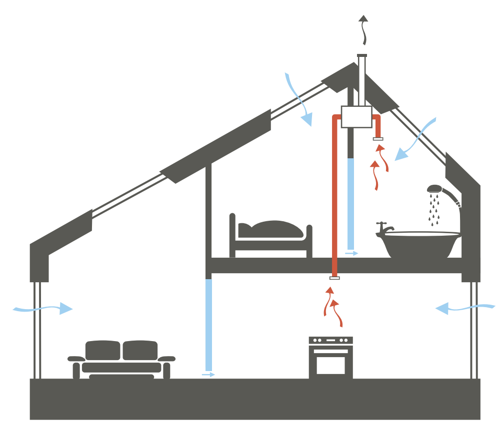


Figure 12: mechanical extract ventilation

Balanced ventilation

Balanced ventilation is mechanical ventilation with heat recovery (MVHR) system that combines supply and extract ventilation in one system combined with a heat exchanger.

Typically, warm, moist air is extracted from 'wet' rooms via a system of ducting and is passed through a heat exchanger before being exhausted to outside. Fresh incoming air is preheated via the exchanger and ducted to the living room and other habitable rooms.

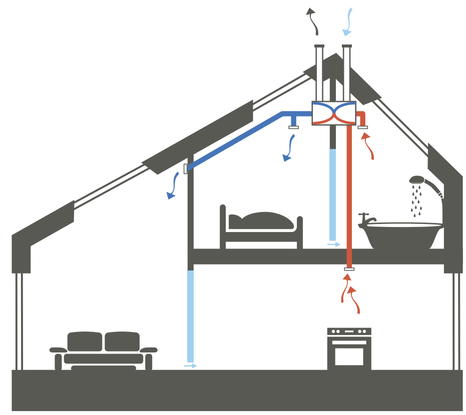


Figure 13: balanced ventilation

Combined with an airtight envelope, MVHR can reduce ventilation losses and heating energy significantly. However, electric fans are needed to keep systems running constantly. More complex systems can increase the risks of reduced efficiency, associated with inadequate installation, commissioning and operation . MVHR systems can also be equipped with demand control and/or a heat pump, although the results are less than with MEV-systems.

Hybrid ventilation

Hybrid systems are a mix of mechanical and natural giving the best of two worlds. In winter when it is cold the mechanical system with heat recovery is used and in spring/summer/autumn when the heating demand is low façade grills and/or windows can supply fresh air.

Regular maintenance should be carried out to that filters and grilles are clean, and that the system is functioning correctly. Fans and heat exchangers will also need to be cleaned regularly.

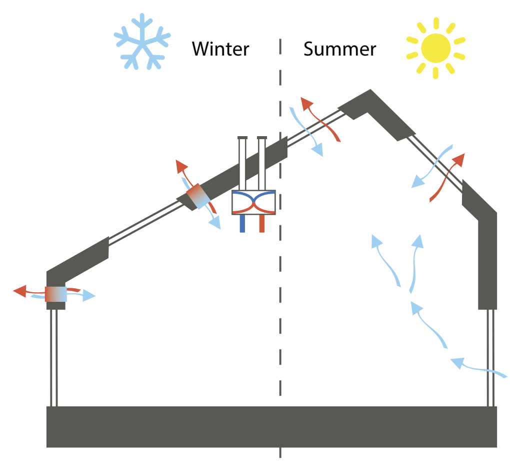


Figure 14: hybrid ventilation

How to design optimally for a good indoor air quality

The basic function of a building is to shelter occupants from outdoor elements and provide a healthy, comfortable environment for productive activity. This statement is deceptive in its simplicity, because the definition of a "healthy, comfortable environment" is not easy to achieve or define.

The first step in achieving a good indoor air quality is source control: preference should be given to building materials and furniture that emit very little contaminant. Choosing materials that are labelled with an indoor climate label that sets limits for emissions is a way of doing that.

When designing a ventilation strategy, a different approach is taken between new construction and existing buildings. However, in both situations, it is important that the users have a clear understanding of the proper operation of the ventilation system. Manuals that give clear and accessible information and guidance are crucial.[9]

New construction
In practical application, demand controlled hybrid ventilation with heat recovery will often be the most energy efficient solution for residential buildings. Since hybrid ventilation consists of both mechanical and natural ventilation systems, the design of the house should accommodate both.

For mechanical ventilation:

- Accommodate space for ducting
  Sufficient space for ducting must be accommodated within the design of the building to accommodate the mechanical ventilation. Layouts that are shorter and with fewer turns are preferable, and this should be considered with development of the layout and form of the building[9]
- Access
  The location of access for maintenance should be considered carefully. All mechanical systems requiring regular checks. Filter changes and cleaning need to be undertaken frequently, as unchanged filters reduce indoor air quality. If the system is in the loft, it seems this is likely to be neglected because the unit is not likely to be readily accessible .
- Noise
  Take the necessary acoustic measures to avoid noise problems, which may lead the occupants to turn off or tamper with the system. It is particularly important that there is no audible ventilation system noise in the bedrooms during sleep.

For natural ventilation:

- Location of ventilation openings
  When planning the location of windows as natural ventilation openings, cross and stack ventilation should be used to its full potential. Stack ventilation is particular important as it is often experienced to cause less draught than cross ventilation. The airflow path through the house is dependent on external wind and temperature conditions.

- The flow path of the air in the house must be designed so that windows in sleeping rooms are not the primary extract openings. An efficient solution in two-storey houses is to place a roof window above the staircase on the upper floor, as this window will often function as an extract for the lower level.

Existing buildings
Designing for good indoor air quality in an existing building can be more difficult, because the existing structure and characteristics of the building limits in the number of possible solutions. Therefore, the most optimal ventilation strategy for an existing building is very much dependent on the given circumstances.

Information that is relevant for the choice of ventilation strategy is:

- How is the building used, how many occupants will be present in the building?
  This affect the dimension of the (mechanical) ventilation system.
- What is the current layout of the building, what functions are at what place?
  When designing the layout of ducting, it is necessary to know how much air needs to go to what location, and where the extraction takes place best.
- What is the structure of the building, how easy is it to make changes?
  If the building has a concrete load bearing structure, it is more difficult to alter the constructi on to accommodate ducting compared to a wooden building.
- How much room is available for ducting and ventilation or heat recovery units?
  If the floor to floor height is limited, it may be impossible to put in a mechanical ventilation system, as there may be insufficient room for the ducts. In this case, a natural ventilation strategy may be the only option.

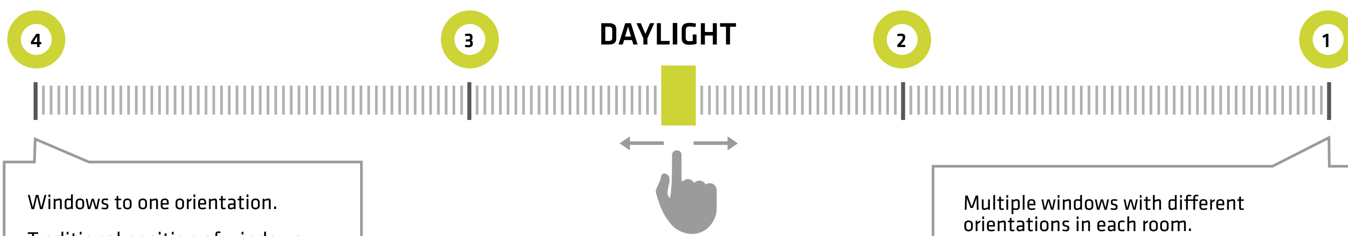
In houses with limited available space natural ventilation can be relevant, as it requires no space for ducting. When more space is available or when the building can easily be modified, mechanical systems and preferably hybrid systems can be considered.

How to optimise an Active House

Comfort

Below an illustration for optimisation of an Active House within Comfort and its 3 sub parameters.

DAYLIGHT



Windows to one orientation.

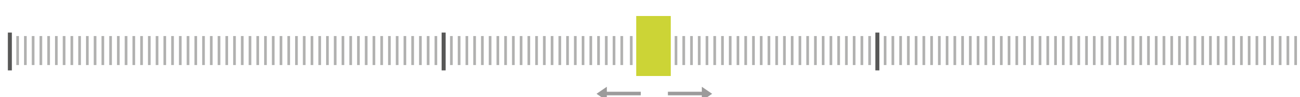
Traditional position of windows.

Multiple windows with different orientations in each room.

Strategic position of windows allowing for balanced daylight contribution.

Position windows to allow for sunlight provision on short days.

THERMAL COMFORT



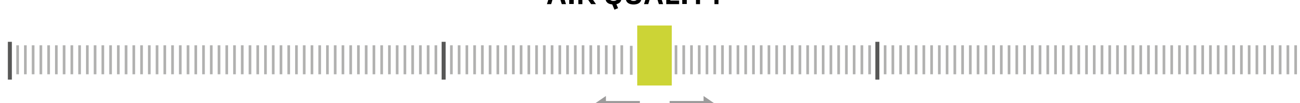
Internal shadings.

Layout and orientation of rooms based on their individual function.

Efficient insulation and thermal mass.

External shading integrated and combined with ventilative cooling and demand control.

AIR QUALITY



Ventilation without indoor climate control.

One side ventilation solution.

Use a ventilation strategy based on demand.

Measure the indoor comfort and CO_2 levels.

Strategic position of devices for mechanical ventilation and natural ventilation in each room.

Own notes on Comfort

Energy

Energy is needed to achieve a comfortable indoor environment throughout the year. The energy type and quantity depend mainly on the differences that exist at each instant of time between given outdoor climatic conditions and desired indoor conditions, as well as on the existing installations, design and quality of the building. The available energy is thus used to ensure user comfort in terms of (day)light, hot water, air quality and indoor temperature.

With the rise of the standard of living, so has the consumption of energy increased, with total consumption sometimes tripling over the past 45 years.

Globally, it is estimated that heating, cooling and electricity for domestic appliances in buildings account for about 40% of the total energy consumption. The energy performance of a building and the energy efficiency of its energy sources are therefore important issues when considering climate change and the reliability of energy supply.

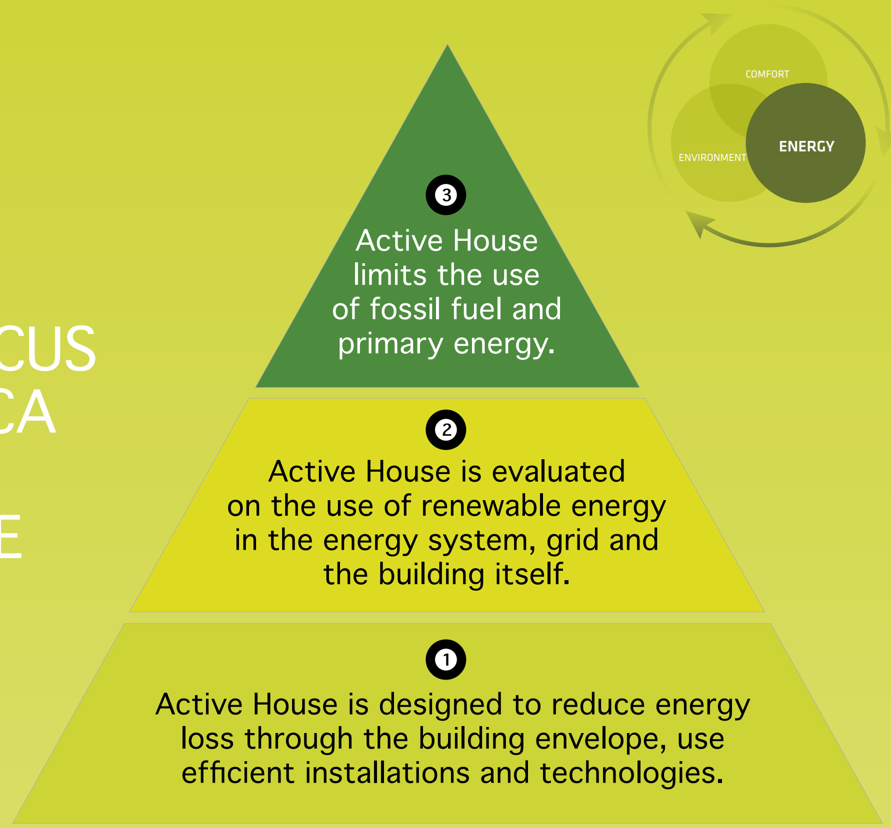
The design, orientation and products used in an Active House must be optimised to demand as little energy as possible and to utilise renewable energy sources as much as possible, following the Trias Energetica[b] strategy. The main focus of this approach is the fact that saving energy by increasing the natural free gains (winter solar heat, natural ventilation, daylight, reduce summer solar heat gain, ...) and by reducing losses and wastes of all kinds represents the highest potential and thus the most sustainable choice. In addition, recovery of waste energy is to be considered wherever possible.

Active House focuses on
1) energy demand reduction,
2) use of renewable energy either on plot, nearby or from the grid and
3) small and very efficient use of regionally or nationally available primary energy resources of fossil origin.

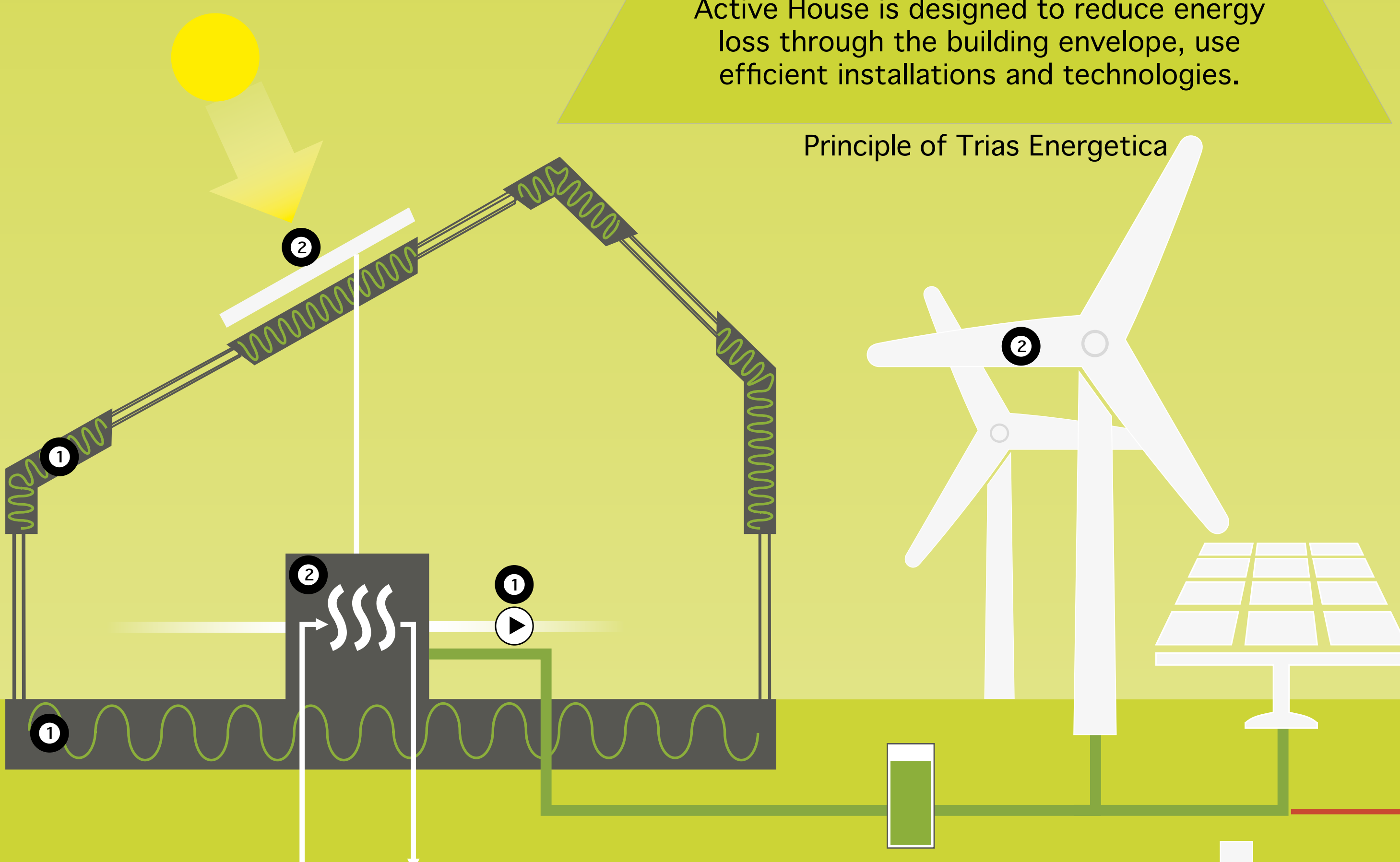
Energy consumption in buildings depends also on user behaviour (occupation, needs, ...). Experience shows that different users in the same building can easily cause a factor of 2 difference in the energy consumption. It is therefore important to guide the homeowners in their use of the building, and the awareness of the energy consumption, with automatic controls, timers, sensors, monitoring systems, energy meters, etc. These are recommended for all Active Houses.

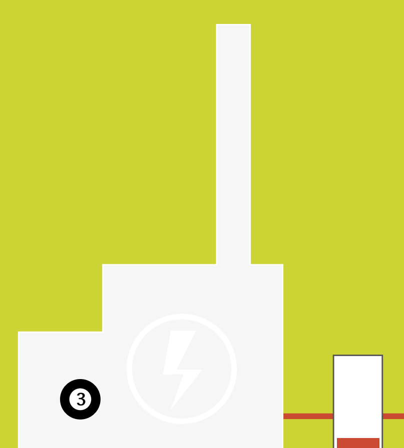
[b] The Trias Energetica strategy in energy efficient design building states three levels of energy saving potential: first, the highest potential relies in reducing energy demand as much as possible by reducing loss and waste, optimise natural free energy gain, then covering the low energy demand from renewable resources wherever possible, and finally, if fossil energy resources are used, they should be used with highest efficiency

AN ACTIVE HOUSE IS DESIGNED WITH FOCUS ON TRIAS ENERGETICA AND THAT THE MOST SUSTAINABLE ENERGY IS THE SAVED ENERGY



Principle of Trias Energetica





GLOBALLY, HEATING, COOLING AND ELECTRICITY IN BUILDINGS ACCOUNT FOR

40%

OF ALL ENERGY USED

Energy demand

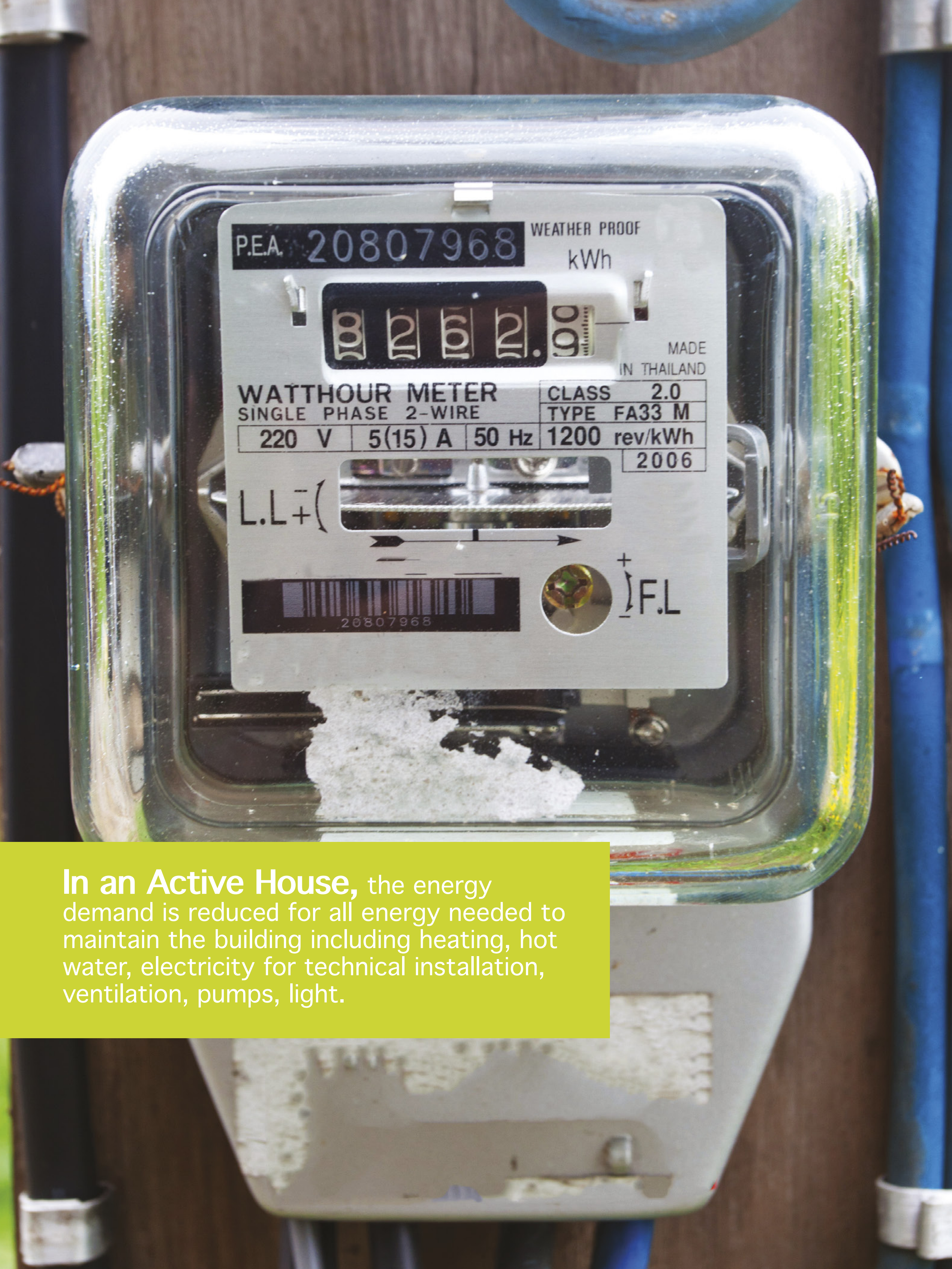
The total energy demand in an Active House includes the energy needed for heating, cooling, lighting, ventilation, hot tap water and other equipment; each use accounts for a part of the total energy demanded in a building to ensure good health and comfort to its users. In buildings, there will always be an outgoing energy flow that represents (wanted in case too much thermal energy is present in summer, or unwanted when thermal energy is desired in winter) loss. The incoming energy is energy supplied energy from incidental internal sources and solar radiation. The key for high energy performance is to ensure that unwanted loss is as small as possible, such as a smaller supply could satisfy all needs

User-coupled energy consumption related to the building, i.e., indoor temperature, lighting and hot tap water, accounts for a majority of the energy demand which may be lowered by intelligent control systems that follow the demand for temperature, moisture and CO_2 levels, and by increased awareness of users on how and when to use energy for both cost effectiveness and availability that still satisfy their needs.

Other user-coupled energy consumption, like appliances, accounts for an additional energy demand which may be lowered by using energy efficient appliances and by increased user awareness on how and when he/she really needs it. The energy for appliances is not included in the Active House evaluation tools, but it is always recommended to acquire best available energy performance products, even at higher costs; on long term, they often prove to be more economical by using less energy.

The design, building orientation and building envelope is essential for the energy demand. Good insulation and an optimised use of daylight and natural ventilation help to optimise the energy balance with a minimum use of supplied energy. Design solutions should include focus on the annual energy demand in combination with the thermal comfort requirement for both winter and summer. Therefore, the design should include optimisation of a building for the actual climate conditions over the year. Be aware during the construction phase: a good project with a bad execution is useless and performance can decrease in a significant way. Monitoring and lessons learnt from feedback are thus essential in progressing toward highest real performance.

Annual energy consumption is usually expressed in kWh per m^2 of useful surface area of the building and will in an Active House be based on the national methodologies. Energy demand is converted to ‘primary energy’ by use of primary energy factors and is explained further in the Primary Energy Chapter.



In an Active House, the energy demand is reduced for all energy needed to maintain the building including heating, hot water, electricity for technical installation, ventilation, pumps, light.

Building-coupled energy consumption

The aim of an energy-efficient design is to create a comfortable and healthy indoor climate that requires a minimum amount of energy. The most cost-efficient way to achieve this in new construction is to use an integrated energy design which focuses on reduction of energy demand, indoor climate, environmental conditions and safety aspects in all decisions from the early design stage. This means that the focus is on "prevention before cure" – all elements are evaluated starting first with the design of the building envelope and installations. Utilisation of passive solutions like solar gain, natural ventilation, solar shading, thermal mass etc. should be considered first, and always before integration of renewable energy to reduce energy use.

An energy-efficient design can be achieved by integrating both passive and active measures. On the passive side are all the design aspects concerning the orientation of the building within the urban design, the compactness and thermal mass of the building itself, the building envelope elements (walls, slabs, roofing, windows), sun blinds, insulation, air tightness, and treatment of thermal bridges. For example, sun facing façades and roofs allow for utilisation of passive solar energy in cold climates and provide an ideal space for solar collectors and photovoltaic (PV) panels. North orientated windows should differ from south orientated windows due to different solar gain. Adequate measures, such as shading and passive summer-night ventilation, prevent buildings from reaching uncomfortably high indoor temperatures during the hot seasons and with no energy consumption.

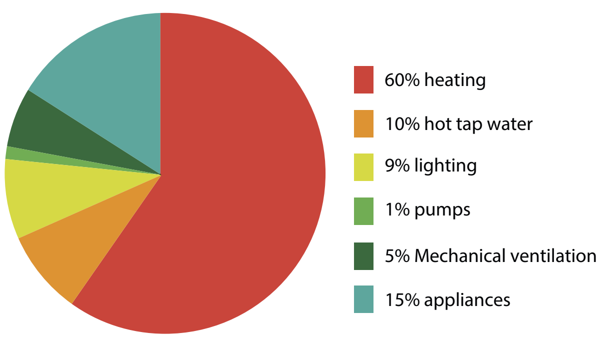
For new buildings, the integration of passive and active measures can form the leading principles for the architect/designer. But in renovation projects, many aspects concerning the buildings orientation and envelope are given. For each project, all measures that could technically be implemented are to be investigated in relation to investment and energy savings potential, such as the outcome is the best under given conditions.

Ventilation has a major impact on indoor air quality and is therefore important for the user comfort and health, as well as for the durability of the constructions since it serves for indoor humidity removal. Ventilation has a significant influence on the energy consumption of a building and should be optimised for both winter and summer conditions. The required level of ventilation should be based on user demand and depends on the type and use of the building, i.e., a higher ventilation rate is needed in schools or buildings with high level of activity. To reach the nearly zero energy level, an efficient ventilation strategy is needed, tailored to the specific location and climate.

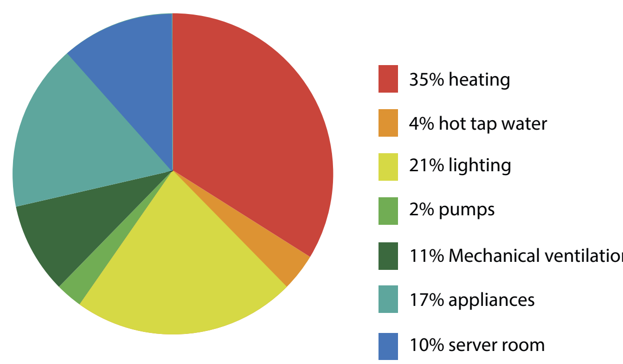
In the pie-figures below, there is a general illustration of the use of energy in buildings, for cold (heating is dominant) and hot climate (cooling is dominant), as well as for traditional buildings on Active House level.

COPENHAGEN

Domestic buildings

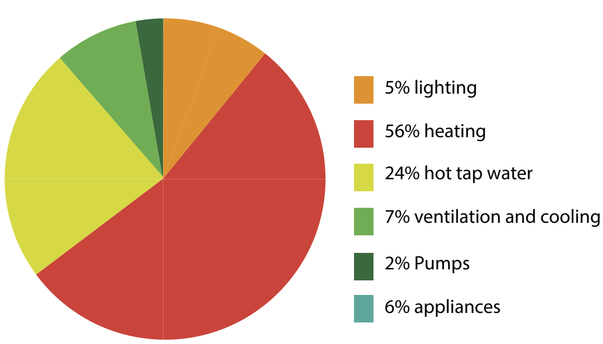


Offices and public buildings



MILAN

Domestic buildings



Offices and public buildings

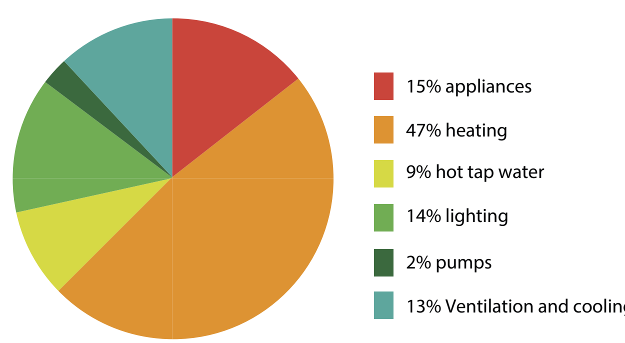


Figure 15: Sources: Kurt Emil Eriksen, VELUX A/S, and Arianna Brambilla Meng, March, PhD student in Building Engineering at Department A.B.C. –Politecnico di Milano, et all.

How to design optimally for low-energy demand in new construction

Recommendations to optimise the building and to reduce energy demand.

Heating

- Optimise building orientation
  Optimising the solar gains during winter time is important to reduce heating needs. A context-aware design optimises the orientation of the building in order to increase the ratio of direct sun availability into the rooms. In cold climate it is preferable to have the day-zones facing south and the night-zones or technical spaces facing north. It is thus possible to let the sun enter and users benefit from the thermal, natural light and psychological effects during the day. Care should be taken to prevent glare, especially at high latitudes when the sun is low in winter.

- Insulate building envelope
  Design the thermal performance of the building envelope in relation to the climate and context. In general, opaque building elements should be energy efficient and contain insulating materials, while transparent parts should contain energy efficient glass with an energy balance that fits the local climate and orientation: high solar gain in cold climates and solar reflection and external shading in hot climates focusing on low heat loss towards to north and solar gain towards east, south and west.

- Prevent infiltration and thermal bridges
  Reducing air infiltration through the envelope is essential. Minimise the discontinuity of insulation in every cross section, angle and change of wall direction, and pay attention to the design of the joint between different construction elements. Locations where the assembly is generally challenging are around windows and doors, at foundations and roof/wall intersections.

- Add thermal mass
  The type of construction and the materials used are important to minimise the energy needs. Constructions with high thermal mass allow dampening and temporal displacement of indoor temperature variations relative to the outside conditions, i.e. ensure small differences between maximum and minimum indoor temperature values and postpone large indoor temperature variation during the day, postponing the need for both for heating and cooling.

- Recover ventilation heat
  Use mechanical ventilation with demand control and heat recovery in order to minimise the energy-losses from exhaust air during the cold season.

Cooling

- Optimise building orientation and shape
  Minimising solar gains during summer time is important to prevent overheating in warm as well as moderate climates. This can be done by using north facing opening for cool natural light or using the shape of the building itself to create shading on the south windows during the summer.
  Shading devices operated by a building automation system can help in meeting indoor comfort, rational energy use, as well as building energy performance. Natural shading like trees and plants can be considered for summer conditions.

- Insulate building envelope
  Design the thermal performance of the building envelope in relation to the climate and context. In general, opaque building elements should be energy efficient and contain insulating materials, while transparent parts should contain energy efficient glass with an energy balance that fits the local climate and orientation. In hot climates especially, roof insulation and insulation in the facades facing the sun help reduce the cooling load of the building.

- Add thermal mass
  The type of construction and the materials used are important to minimise the energy needs. Thermal mass accumulates heat during the hottest hours which can be discharged during the night, when outdoor temperatures are lower. A well designed system harmonises the cycle of charge-discharge of heat with the weather stress and conditions.

- Discharge the system –increase the ventilation ratio
  Weak or lack of ventilation in well insulated buildings can be one of the reasons of indoor overheating; the incidental gains (from solar radiation, appliances, users) are trapped inside the building and heat the air, with almost zero transfer rate through the envelope. Increasing the ventilation flow rate and use of night ventilative cooling are recommended strategies for removing excess heat. Other options should be considered secondary.

Ventilation

- Natural Ventilation
  In order to maximise the effect of the natural ventilation, windows should be placed in couple: north-south or low-high floor, such that a sufficient pressure gradient is created to cause air draught throughout the building.

- Demand control
  If purely natural ventilation does not provide the required comfort or energy-performance, couple a mechanical ventilation system with demand control, i.e. an automation device. This will reduce drastically the electricity consumption of the fan, compared to a full mechanical system, and ensure a good indoor air quality at the same time.

- Cooling and heat recovery from ventilation
  When mechanical ventilation is used/designed, recovery of energy from exhausted air by use of a heat exchanger is strongly advised, for both heating and cooling purposes.

Lighting

- Increase the natural light availability
  To reduce the energy need for artificial lighting, the best way is designing an airy and bright indoor space. Using as much natural light as possible is the best way to reduce the use of artificial light, i.e. lighting. Try to use systems that are based on daylight zones: nearby windows lights go off, in darker places deeper in the building they stay on. On locations where lighting is only occasionally needed, such as hallways, use switches that are linked to movement sensors.

- Use diffuse natural light
  The windows placement should ensure use of as much natural light as possible. However, care should be taken to prevent glare. North facing windows transmit mainly diffuse light, as they are deprived of direct solar radiation.

- Light oriented design
  Being aware of lighting issue during the design phase is important. By using little tricks, the brightness of the space can be increased, cutting the needs for artificial lighting. One option could be the use of light colours, such as white, for the inside walls and/or other surfaces: the light is thus repeatedly reflected and easily spread in the rooms.

Building services

- Use best technologies
  Be aware of the energy efficiency of the technical installations and use the best available technologies for pumps, control systems, heating system, water circulation systems and optimise those to meet the specific demand.

- Use of intelligent solutions
  Use intelligent solution that can optimise the technical systems as well as switch systems on of de pending on the need, as an example by use of intelligent water circulation systems that act on demand rather than systems with continually use. Use systems that can be optimised in combination with the user demand depending on time of day and the year.

- Monitor the systems and the use
  Monitor the building and give users information and feedback on the use of energy. Focus on user in formation on energy uses for main technologies, indoor temperature, CO_2 levels, humidity in combination with the outdoor climate. Make at least one evaluation for the whole system per year.

Hot domestic Water

- Reduce the use
  Use water saving equipment to reduce the use of hot water at taps. Optimise the system to reduce the need for heating and evaluate use of local heating close to the taps in larger systems, in order to reduce the heat loss during transportation.

- Optimise the systems.
  Use a heating system that are optimised for use of renewable energy and with possibilities for controlled and intelligent demand. Secure well-insulated water pipes in order to reduce the heat loss.

Own notes on energy

Energy Supply

In an Active House, the energy demand for the building has to be lowered as much as possible using passive energy saving strategies, while the resulting small demand should be supplied in the most sustainable and cost effective way depending on what energy sources are available in the building, in nearby system or in the grid.

Energy supply to an Active House should, to the utmost extent, be supplied from renewable energy sources, which by definition cannot be exhausted. Examples of renewable energy are electricity from wind turbines or photovoltaic cells, solar thermal energy, hydropower, biogas, energy supplied by heat pumps (provided that the energy supplied to the heat pump originate from renewable energy sources and that the primary energy reservoir is unlimited). Non-renewable energy sources are usually of fossil origin, such as coal, gas, oil and nuclear.

The renewable energy can be renewable energy installed on the building, on the plot, nearby systems or in the grid. When renewable energy equipment is not installed in/on the building of an Active House or within its the vicinity, it must be proven that the energy used from remote collective sources (like district heating/ cooling and electricity grid) comes from renewable energy resources.

In addition to ensuring the most sustainable source of energy is utilised, and effort should be made to match supply and demand. For example, during the day, when the sun is shining and there is a surplus of electric energy being generated by photovoltaic cells on the roof, it would be an optimal time to run the washing machine, rather than waiting until the evening, when general electric demand is high and the supply from photovoltaics is low.

The goal is that the energy supply to an Active House shall be based on renewable and CO_2-neutral energy sources.

Renewable energy sources

Renewable energy sources include wind, solar, geothermal, ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. All solutions available on the market can be taken into consideration within renewable energy supply to an Active House as long as it is proven that they are cost effective.

Electric/Grid

- Wind turbines converts wind energy to electricity using a generator in the wind turbine. Such systems may be of large or medium size and provide electricity to the collective grid.
- Hydropower units usually are on-grid electricity suppliers.
- Combined heat and power (or heat, cooling and power) may be produced in cogeneration plants of different installed power that supply energy to a number of end-users. Such plants have high efficiencies, but when an Active House is supplied, it is important that the primary energy used be of renewable kind, i.e. biomass, hydropower or waste.

Electric/nearby and on the building

- PV (Photovoltaic) systems, which convert solar radiation to electricity, are more and more popular on residential and non-residential buildings. The PV cells needs to have an unobstructed view to the sun, i.e. no or very few shading objects. If more electricity is produced than consumed, the excess can be stored in batteries or fed into the main electric grid.
- Small wind turbines may be installed on the roof or near the building, provided that enough strong air currents are locally available for most of the time during the year. In all cases, they need auxiliary devices such as converters and storage batteries. As they produce at the same time as larger wind turbines in the grid, the cost effectiveness should be evaluated.

Heat/nearby and on the building

- Solar thermal systems convert solar radiation to thermal energy (typically hot water) using a solar collector and a storage system. Solar collectors require unobstructed view to the sun, i.e. no or very few shading objects. Since the system efficiency is higher when the output is delivered at low temperatures, solar thermal systems are suitable for low-temperature heating. To achieve higher temperatures, secondary heating sources (e.g. electrical resistance) can be used. Solar thermal energy may be used for both space heating or hot tap water
- Geothermal heat pumps transfer energy from the ground to the heating fluid (usually, air or water). Heat pumps are best suited for low temperature applications. Only heat pumps with an output that significantly exceeds the energy needed to drive it, i.e. with high COP (coefficient of performance) values, should be taken into consideration.
- Biomass and biogas may be used in traditional boilers to produce high-temperature heat. As with other boilers, a chimney is required to release the flue gas to the surroundings. In large industrial plants, this heat may be further used to produce mechanical and electrical energy.

How to determine the best renewable energy source

Integration of renewable energy should be balanced with the need for energy. Energy needed for heating is required during the cold season and the renewable energy used should therefore be based on renewable energy sources available during that season.

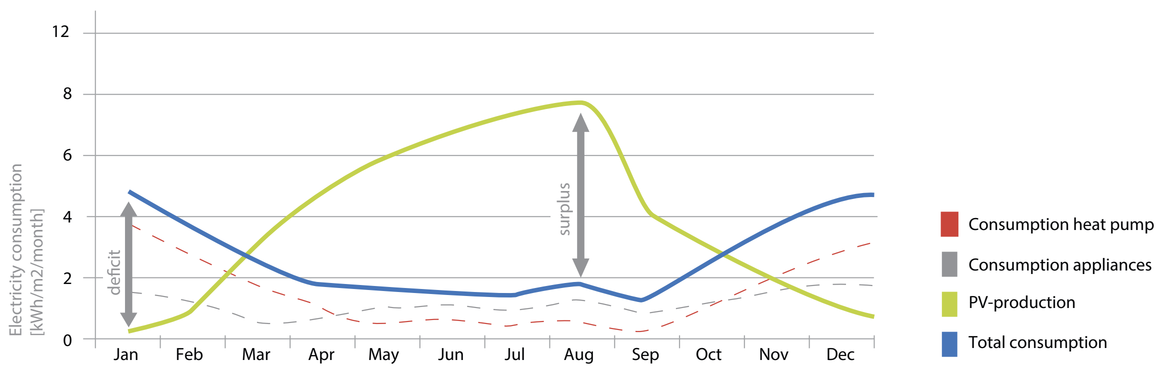


Figure 16: Illustration of the production and consumption during one year.

The integration should also be evaluated on long-term perspective with evaluation of the system based on cost effectiveness, including long-term energy costs and the long term possibility to exchange with other systems as well as a estimated prize levels, by overproduction in the grid.

Balanced evaluation
A balanced solution may require integration of more than one renewable energy source.

For example, renewable energy for

- the heating demand can be supplied by heat pumps driven by renewable energy from windmills, and/or solar thermal panels and/or cogeneration units using biomass.
- the hot tap water can be produced by a combination of heat pumps and solar thermal panels or electricity from PV panels discharged through a resistor.
- the electricity throughout the year can be produced by wind turbines and PV panels.

The balance between the amount of renewable energy produced on the building and plot, and the amount of renewable energy supplying the collective grid or district-heating system should be optimised and based on cost optimal solution. Therefore, there are no specific recommendation to the kind of renewable energy to be used. It will always depend on where the building is placed.

For example, if the building is placed in an area with energy supply from district heating based on renewable energy, it will often be best to integrate the building into the district system, while if the district heating system is remote or unavailable, it may be best to use boilers on biogas or heat pumps with PV or other renewable electricity supply.

Design
Renewable energy installed on the building should as far as possible be integrated into the design and not an add-on.

Primary energy performance

The energy used in a building is produced and transported from the local or remote source and then distributed to the final use locations. This production-transport-distribution chain includes losses that may be of significant level, especially for remote sources and/or inefficient equipment and piping systems. Therefore, since the final objective of all energy efficiency strategies is to diminish losses of any kind and preserve limited resources, it is always recommended to indicate the primary energy consumption associated with the final energy use (energy demand) in a building. This approach encourages designers and engineers to choose those solutions for the building and its installations that lead to the lowest primary energy consumptions, i.e. lowest use of fossil resources and lowest greenhouse gas (GHG) emissions.

Primary energy is the energy that has not been subjected to any conversion or transformation process. Conceptually, primary energy can be non-renewable or renewable. In the approach of saving limited natural resources by using available renewable energy sources, it is of interest to define primary energy as associated only with the energy content of the fossil matter as it exists in nature. This definition is widely used in assessing overall energy performance of engineering systems and will be used in connection to the Active House performance evaluation as well.

The ratio between the primary energy at the inlet of the production unit and the energy consumed at the end-user (also named final energy, energy demand or energy supply) is called conversion factor. Each type of energy used in the building has its own conversion factor that depends on many factors, like production-transport-distribution losses, as well as on the combination of natural resources used over this whole chain. For example, the conversion factor for electricity ranges in most countries between 1.8 and 2.7, meaning that the primary energy associated with the electricity used in the building is 1.8-2.7 higher. District heating often has a conversion factor between 0.6 and 1.0, depending on the renewable energy content in the resource mix and, if it is the case, on the higher efficiencies of cogeneration units compared to the individual heat and electricity production.

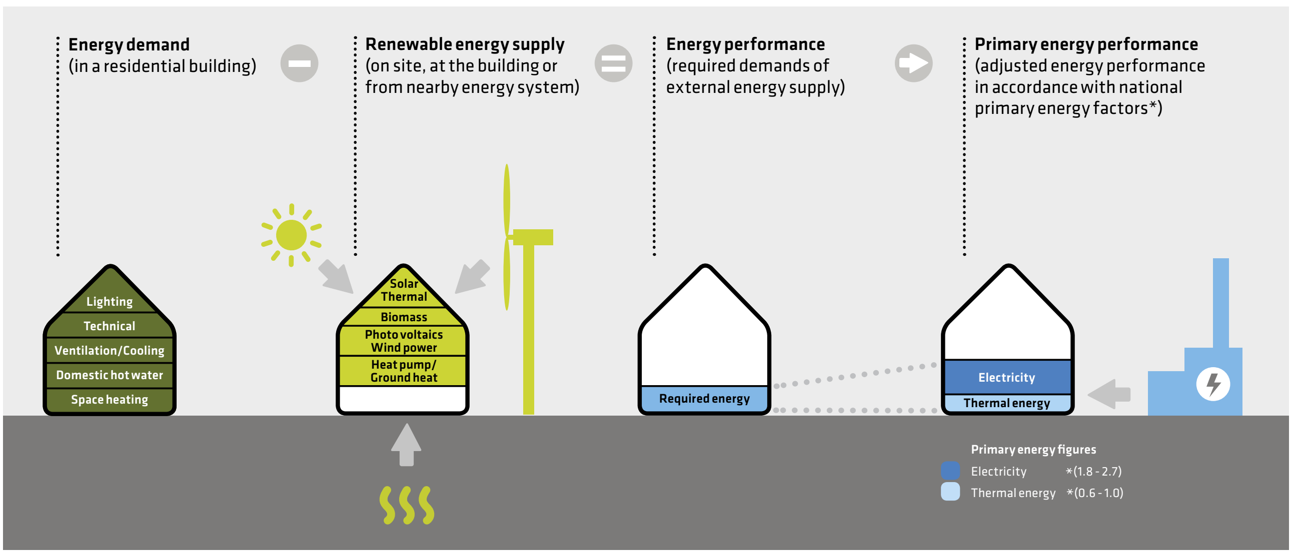
The calculation of primary energy follows the principles stated in national legislations, which in Europe are derived from the Energy Performance of Buildings Directive. Most often, the primary energy is calculated only for the difference between the total energy demanded by the building normal operation and the renewable energies used in/on the building or plot to cover the demand. Only if this approach is used, one can talk about zero-energy buildings or energy-plus buildings, one of which is also the Active House, where the demand is totally supplied with renewable energy or the energy produced from renewable sources is even higher than the building energy demand. In the former case, the surplus of energy may be transferred to collective energy systems like the grid or district heating piping to be used by other end-users.

If the Active House tool is used, the primary energy calculations are made directly in the program, provided that the national conversion factors are specified.

The annual primary energy performance of an Active House is low and is based on national figures on primary energy.

How to determine primary energy consumption

In order to evaluate an Active House the specific primary energy factors for the specific energy source and the specific region are needed. Normally, the primary energy factors for electricity and district heating will be needed. However if other sources, like gas or local boilers in combination with renewable and fossil energy, are used, those should be used.



If the specific values are not available in the concept, face a simple first evaluations of an Active House using conversion factors of 2.5 for electricity and 1.0 for district heating and 1.0 for gas.

Qualitative parameters energy validation on site

The quantitative parameters of an Active House include recommendations to Energy Demand, Energy Supply, and Primary energy performance. In addition, there are qualitative recommendations to Energy demand and supply, Energy validation on site and Management of the energy use in the building.

Energy Demand
Active House does not set specific requirements to individual products or solutions. It is recommended to optimise the design solutions for the whole building and its installations and to choose the best performing products and solutions and evaluate those on a cost optimal basis. This will, among others, require that individual solutions should be compared on their performance, service and life time and not only on price. As an example, a circulation pump that has intelligent control can be more cost effective than one which is running constantly, even though the initial costs are higher. It can also be relevant to develop a water based heating system divided into zones, and to use individual solutions for each zone, rather than one larger zone.

Energy Supply
Active House does not require specific solutions on the energy supply, but recommends to look at the specific solutions available in the area where the building is built. Integration of renewable energy in the building should be based on cost optimal solutions. Renewable energy that is integrated should, where possible, be a part of the architectural design and should be evaluated from both an engineering and an architectural point of view.

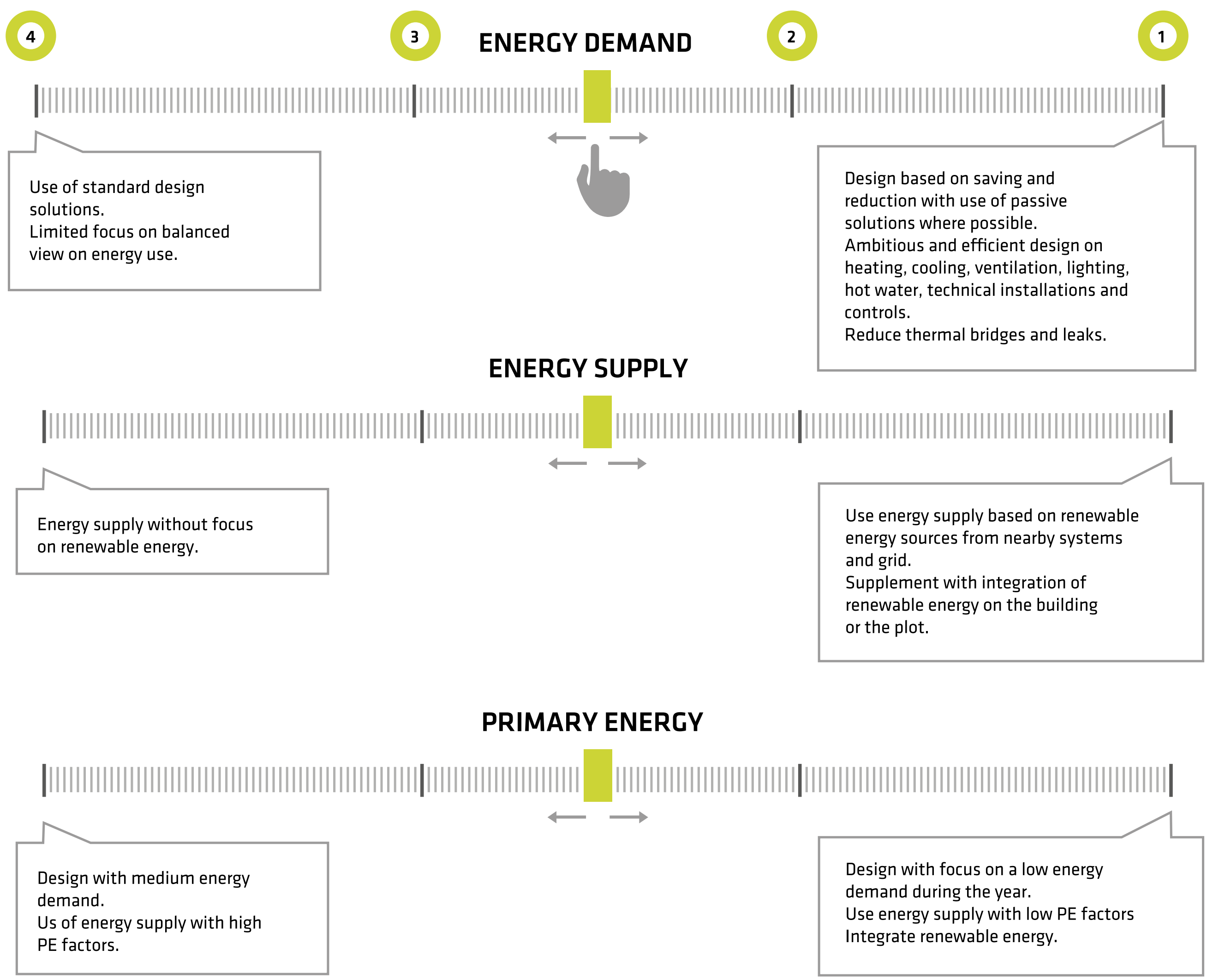
Energy validation on site
It is strongly recommended to check the quality of the construction on site during the construction process. Such evaluation should include assessment of the individual products and if the delivered services are equal to those specified in the design, as well as a site control of quality of the works performed. Such controls should be performed along the construction period such as to allow corrections before works are finalised. Experience shows that uncontrolled works may lead to energy consumptions that are 10 to 20% higher than the estimated values in the design phase.

Management of energy use in the building
The final energy consumption in buildings depends significantly on the user behaviour and the technical solutions installed in the building. Experience shows that different user behaviour in the same building can easily cause a factor of 2 or more on the energy consumption. It is therefore important to help the building users by guiding them on how to perform a simple monitoring and on how to efficiently use the building installations. The energy consumptions and some comfort parameters (e.g. indoor temperature and humidity, CO_2 level) should be monitored on a regular basis and displayed on a visible spot in the building or on a handy device. When renewable energy is used, it is recommended to monitor it as well. This approach allows the building users to act if the performance changes negatively.

How to optimise an Active House

Energy

Below an illustration for optimisation of an Active House within Energy and its 3 sub parameters.



Own notes on energy

Environment

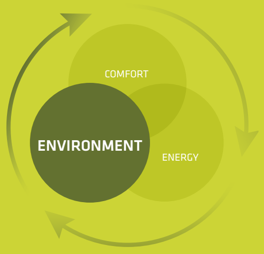
The use of resources and materials in buildings account for up to 24% of our resources worldwide[12]. Therefore environment is chosen as one of the three main parameters in the Active House vision and therefor LCA evaluation and sustainable sourcing as well as use of water are the main parameters for environment in Active House.

Introduction
Solving climate change is probably the biggest environmental challenge humanity has ever faced. There is enough scientific evidence that the increasing concentration levels of greenhouse gases in the atmosphere will result in an increase of the surface temperature; with social, environmental and economic implications. This has resulted in global efforts to reduce greenhouse gas emissions and increase environmental efficiency. Currently, around 33% of the global greenhouse gas emissions from human activities can be attributed to the building sector .

Regarding environmental challenges greenhouse gases is not the only type of emission that can be harmful for the environment. Therefore, according to the TC-350 standards (sustainability of construction works), the environmental loads are described by 5 different categories of emissions (equivalents); Global warming potential CO_2-eq, ozone depletion R_{11}-eq, photochemical ozone creation potential C_3H_4-eq, acidification potential SO_2-eq, and eutrophication PO_4-eq. Besides that, the primary energy redrawn directly from the nature is also part of the evaluation.

Why Life Cycle Analysis (LCA)?
LCA has positioned itself as one of the most widely used tools for environmental assessment of materials and buildings due to its flexibility and the possibility to include every stage in the life cycle of the analysed system. This flexibility allows the practitioner to focus on the whole life cycle for a specific building, which is in line with the holistic scope of the Active House vision.

In the Energy chapter of these guidelines, there is a focus on increasing energy efficiency in buildings and eco-efficiency in the energy supply. This focus mainly refers to the use stage of the building as this is the most environmentally and energy intensive phase. This focus leads to substantial reductions of environmental loadings in buildings, but mainly in the use phase. As a result, the relevance of the production of the building and its materials in relation to the use phase increases with time and the relevance of a holistic approach concerning the whole building lifecycle becomes more relevant.



ACTIVE HOUSE AIM TO HAVE A POSITIVE IMPACT ON THE ENVIRONMENT

IN 2014 IT TOOK HUMANS

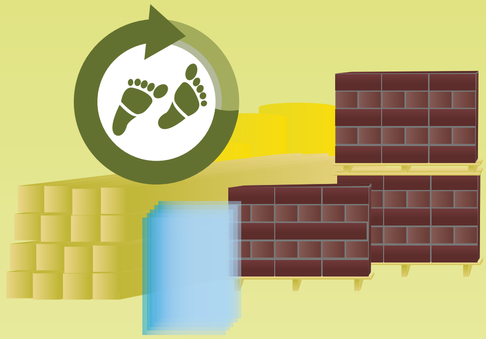
8 MONTHS

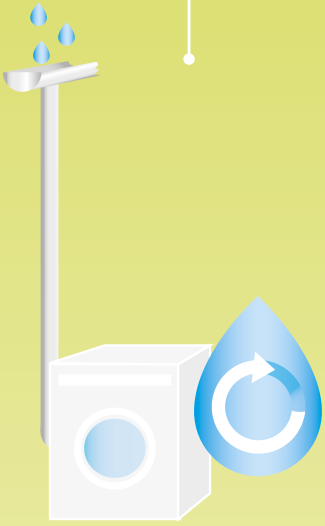
TO USE THE THE RESOURCES, THE EARTH IS 12 MONTHS TO PRODUCE

Minimise freshwater consumption
The depletion and scarcity of global freshwater resources are escalating and thus it is becoming increasingly important to consider water consumption. An Active House minimises the use of water.

Limit the environmental loads during the whole life cycle of the building
The process of constructing a new building causes various emissions to air, soil and water, which have different impacts on the environment. An Active House minimise the foot print and is evaluated for 6 environmental parameters.

Take sustainable constructions and sourcing into consideration
The global resources are limited and it require focus on sourcing and use of recyclable materials. Design of an Active House requires focus on sustainable use of materials.





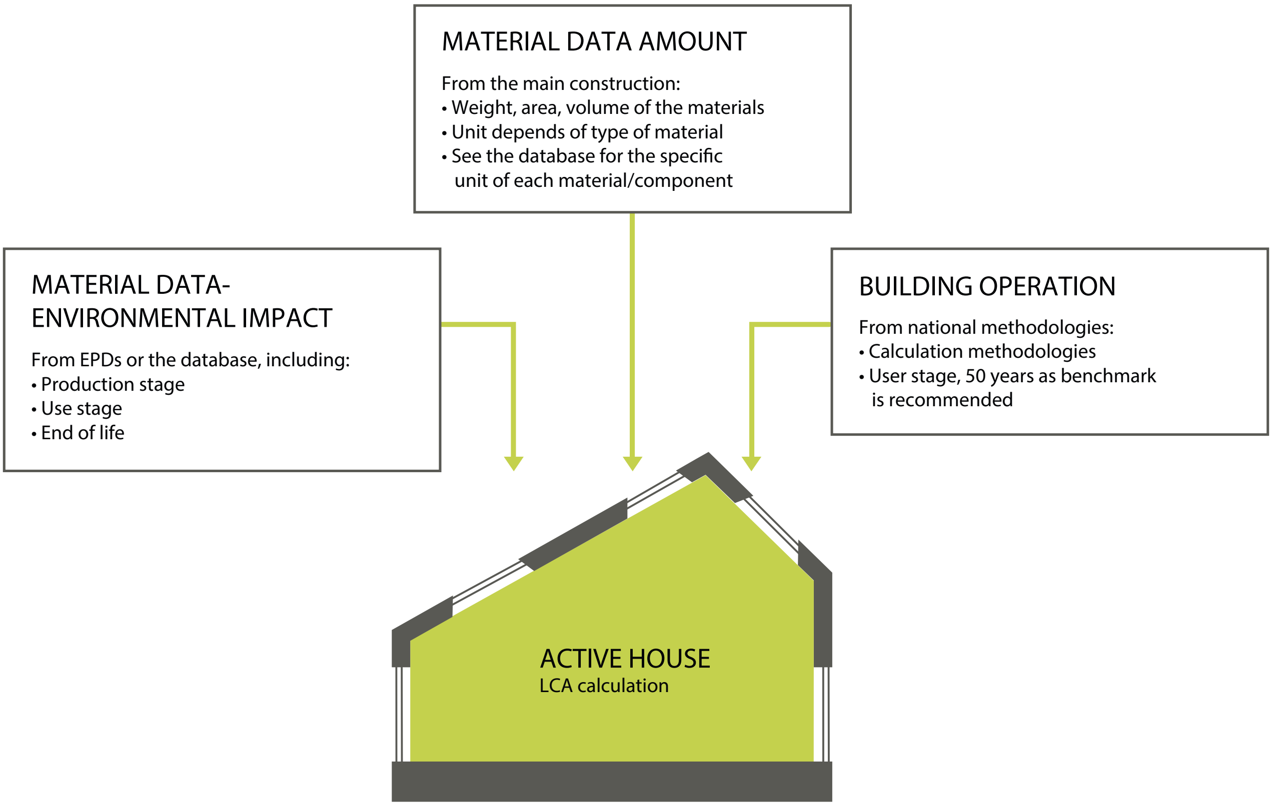
Environmental loads – LCA

The environmental load is part of the Active House shown as one of the nine indicators (See Chapter 3.1 in the Active House Specifications). The evaluation focuses on the total environmental loads from the production of the materials, from the use stage and from the end of life stage of the building.

There are many standards for LCA and its methodology. Among ISO standards there is a complete series dedicated to environmental issues, ISO 14025, 14040 and 14044 being the most relevant for LCA practice. In a European context, the European Committee for Standardisation (CEN) has released a series of standards for sustainability of construction works. From this series two standards are specially related to the work in this study; one is EN 15804 with core rules for EPDs and the other being EN 15978 with calculation method for the assessment of environmental performance of buildings. Finally, the prEN 16485 is under development, which provides Product Category Rules (PCR) for wood and wood-based products to be used in construction.

The purpose of an LCA calculation is to calculate the building's overall environmental impact through its life cycle. An LCA calculation includes environmental impact from the product stage, construction process, use stage and end of life. On the material level an LCA must be performed according to EN15804. The result of the material-LCA calculation (environmental product declarations, or EPDs) can be used in the building-level calculation. At the building level an LCA calculation must be performed according to EN15978 and thus includes both the environmental impact of the materials and the building's operation. In Active House the LCA calculation are to be conducted for a building-lifespan of 50 years.

The following diagram shows the input that is needed to carry out an LCA calculation.



When designing an Active House and conducting a Life Cycle Assessment, it is important to know and consider the different solutions and their impact on the environment.

Materials

In order to calculate an LCA of a building, it is necessary to have LCA data for the individual building. These data can be either product-specific through environmental product declarations or as generic values through various public databases. In the Active House LCA tool both data form specific EPDs or generic values from the database (ökobau.dat) can be used. If you wish to use specific EPDs the stages A1-3, B1-7 and C1-4 (see Figure 18) are to be declared to the extent it is relevant to the individual building material. It is possible to enter the results of a specific EPD and use it in the Active House LCA tool used for the LCA calculation of the building. EPDs according to EN15804 is downloaded through different program operators. The program operator must be part of /approved by the European organisation ECO-platform.

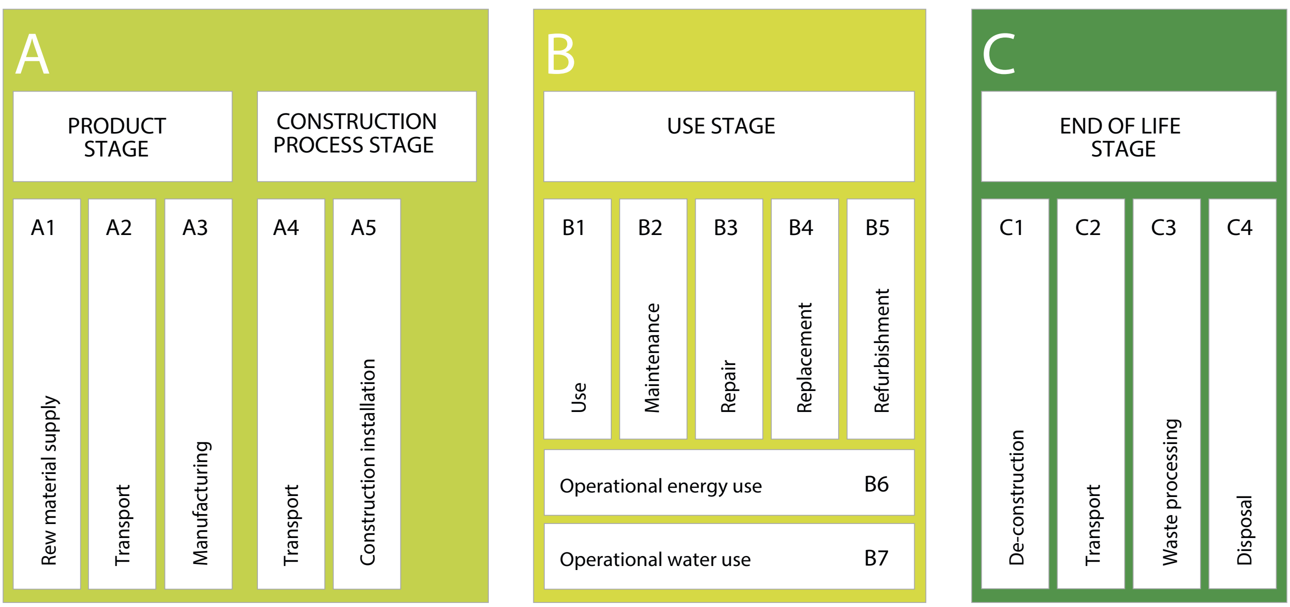


Figure 18: Principles for different stages in a buildings lifetime

Achieving low environmental impact from the materials requires selecting materials with low environmental impact during production, but also a strong focus on minimal maintenance during their lifetime. Particularly the durability or technical lifespan is important, as materials with a short lifetime (under 50 years) according to the standard will be counted multiple times in the LCA calculation - both in terms of environmental impacts of the production and disposal (end of life stage). At the same time, it is beneficial to select components whose raw materials are recyclable and adequate for later reuse. Via the Active House LCA tool, building analysis and scenarios with different materials can be carried out to find the best material composition for the specific project.

Use phase

According to the Active House Specifications, the building energy consumption during the use-phase shall be calculated in accordance with national regulations. The results from the national calculation are transferred to the Active House LCA tool and represents the stage B1 in Figure 18. Achieving low environmental impact of building operation / use phase is ensured by reducing the building's energy demand equivalent to a good score in Active House specification chapter 2.1 together with the use renewable energy in the energy supply to the maximum extend as evaluated in the Active House specifications chapter 2.2.

Design guides:
The following 5 statements are a short list of recommendations given in order to reach a good result and thereby a building with low impacts on the environment:

- Since the calculation is based on the environmental loads from the use stage and the construction phases, it is important to analyse both the use of materials and the energy demand and energy supply of the building
- Use the LCA calculation tool to analyse different materials for the building. Remember that some building materials might have relatively high environmental loads, but might also have a long lifespan. Consider this along with the expected lifetime of the building when choosing building materials.
- Be aware of side-effect like thermal capacity (indoor materials), easy to clean surfaces and choose low-odour and low-emission construction products.
- As a rule of thumb, take the highest concern when choosing the construction materials with the largest mass (the heaviest materials).
- Choose construction materials that to the largest extend possible consists of recycled material.

Result
Figure 19 and Figure 20 show the results of a typical LCA calculation. The graphs show the environmental load divided in constructions and operation and divided by construction elements.

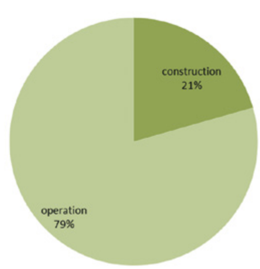


Figure 19: Percentage of total environment impact (Construction and operation)

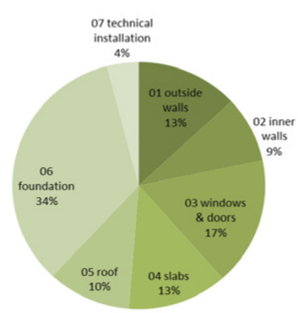


Figure 20: Percentage of total environmental impact divided by construction element

Global Warming Potential [GWP]	16,78	kg CO_2-eq/m²a
Ozone Depletions Potential [ODP]	2,33E-06	kg R_{11}-eq/m²a
Photochemical Ozone Creation Potential [POCP]	0,0027	kg C_3H_4-eq/m²a
Acidification Potential [AP]	0,034	kg SO_2-eq/m²a
Eutrophication Potential [EP]	0,004	kg PO_4-eq/m²a
Primary Energy [PE] non-renewable	66,9	kWh/m²a

The actual loads on the 6 categories needed for the evaluation are shown in the table.
The 6 categories are described in the Active House Specifications and the Active House Score is calculated based on the results for 6 categories.

Tools
Performing an Active House evaluation requires use of LCA-tool and data according to the mentioned standards. Active House provides the user with a LCA tool specifically created for this purpose.

Fresh water consumption

Fresh water and potable water
Potable water is a limited resource on Earth. Less than 1% of Earth's water is fairly available for consumption as most water is saline and 2/3 of the fresh water is locked up in polar ice caps.

Not all fresh water is potable! Much surface fresh water and even ground water is unsuitable for consumption (non-potable) without some treatment due to chemical or biological contaminants –preservation of our potable water is important to us all!

Fresh water consumption
The water consumption per capita per day differs from country to country due to water prices, water availability, climate, living standards, political focus etc. The general picture however is that almost 80% of the public water supply is used in residential or light commercial buildings (BDEW, 2013) allocating a major role in water preservation to us all.

Water preserving choices can significantly reduce water waste i.e. the overall consumption level without compromising comfort. About 50% of the water consumption (today mainly served with precious potable water in a residential home) can be replaced by rainwater or recycled water.

Grey water is wastewater without faecal matter. After treatment the grey water and rainwater can be recycled and re-used (toilet flushing, laundry, cleaning). Consider the energy costs and investment. Treatment is sometimes also needed for rainwater.

Black water from toilets can be treated and re-used in toilets, but this is a more complex and energy intensive process.

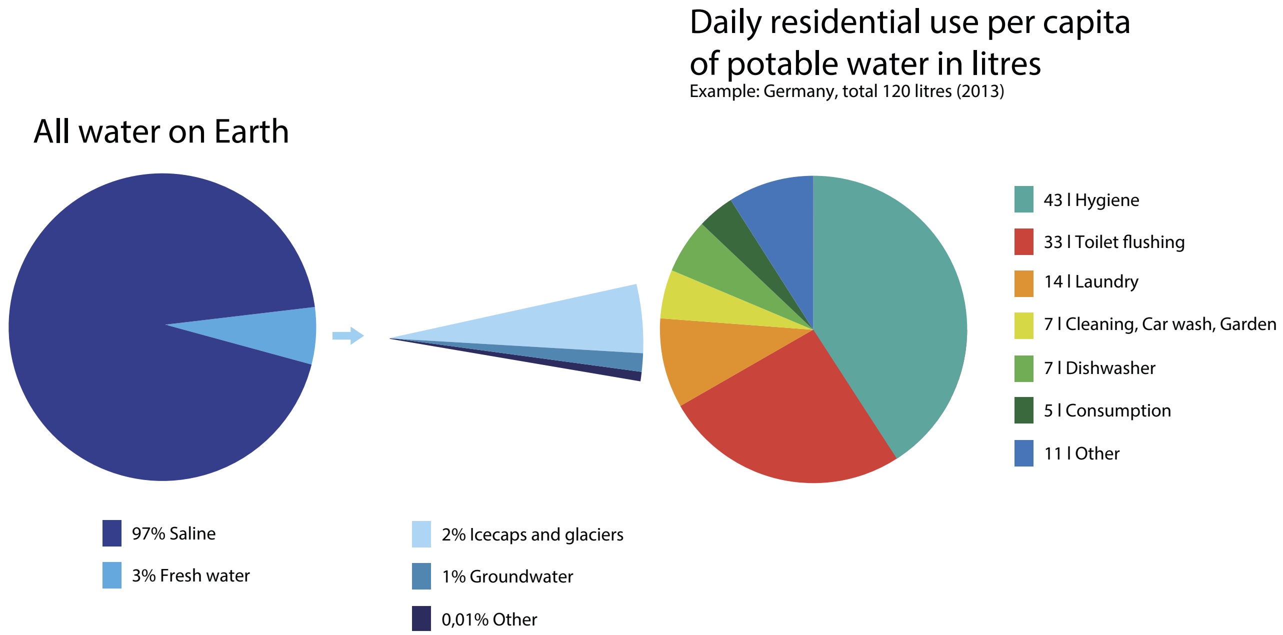


Figure 21: Availability of water on earth. (Source: Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

Freshwater consumption in an Active House has to be considered and reduced because fresh and clean water becomes a limited resource.

Minimisation of freshwater consumption

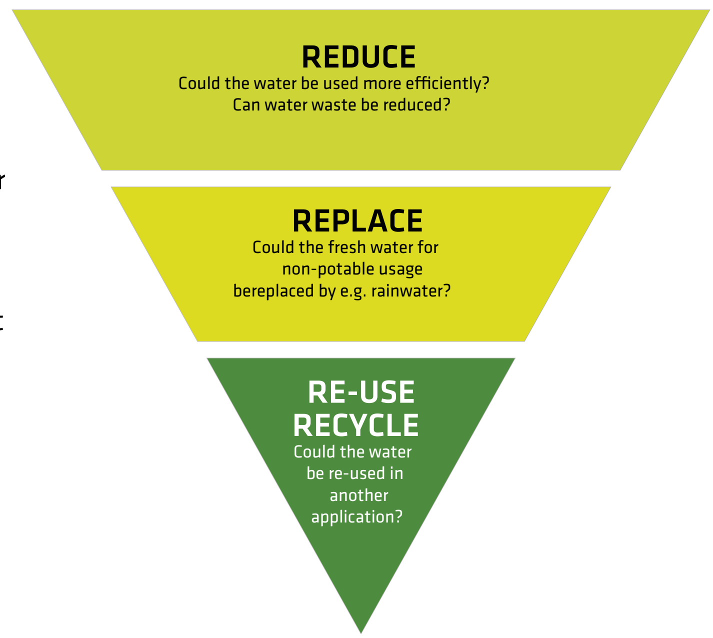
The minimisation of the water footprint of an Active house is evaluated with the national use of water as reference and is classified on the specific minimisation compared to the national level.

It can be recommended to use a water minimisation strategy following the principles, reduce, replace and re use.

Reducing water consumption
An ecological and economical smart decision in the short and long term. Water stress is increasing globally and so will water prices.

Note: When choosing low flush toilets, consider the self-cleaning capabilities of the sewage pipes.

Immediate availability of hot water at the point of use from recirculation (e.g. to the shower) significantly reduces the waste of expensive, energy-intense hot water and increases comfort by fast delivery of hot water.



Replacing mains water with rainwater
Reasons for using rainwater:

- Financial: Saves money by reducing the water bill
- Ecological: Reduces the extraction of groundwater (a scarce resource)
- Technical: Reduces the excessive stress on the municipal sewage system and the treatment plant, soft water reduces lime stone
- Societal: De-centralised water tanks for rainwater systems reduce the stress on sewerage systems during heavy rain and lower the risk of flooding.

Factors to take into consideration:

- Size of roof area, roof material, pollution from the surroundings, rainwater supply (precipitation), space for rainwater storage tank, filtration, regulations for prevention of contamination of mains water, maintenance.
- Note: Dual pipe system must be a part of the design.

How to design around optimal water consumption

All cost-effective water efficiency measures should be put in place before alternative supplies are considered.

1. **Reduce**
   Install water saving components; shower heads, taps, toilets, washing machines, dishwasher, easy cleaning surfaces, domestic hot water recirculation pump system.
2. **Replace**
   Rainwater can replace the non-potable water usage in a building.
3. **Recycle**
   Recycling of grey water e.g. from showers and washing machines to be used for toilet flushing and irrigation after treatment or black water reuse.

A water saving strategy should include a checklist of initiatives with reduction, replacement and reuse of water.

Check list (examples)

Reduce
- Low flow shower heads
- Low flow faucets/taps
- Low flush toilets
- Low water washing machine
- Easy clean surfaces
- Hot water recirculation
- Adaptive hot water recirculation

Replace
- Rainwater harvesting for toilets
- Rainwater harvesting for laundry
- Rainwater harvesting for irrigation
- Rainwater harvesting for car wash

Re-use
- Grey water re-use for toilets
- Grey water re-use for laundry
- Grey water re-use for irrigation
- Grey water re-use for car wash
- Grey water heat recovery
- Black water re-use for toilets

Sustainable construction

When designing an Active House, it is important to evaluate recycled content and sourcing. These considerations are very much in line with development that is seen in other parts of society. Responsible sourcing of materials is reflected in EU regulations.

Sustainable use of materials is increasingly important to consider, which is evident for example in the "EU Roadmap for Resource Efficiency in Europe" which sets targets for year 2020 in relation to renovation and new constructions: "In 2020 the renovation and construction of buildings and infrastructure will be made with high resource efficiency... 70% of non-hazardous construction and demolition waste will be recycled".

The suggestion in the Active House Specifications for certified Environmental Management Systems (EMS) at suppliers of materials assists in securing that materials are produced in environmentally conscious manner.

When designing an Active House, it is important to evaluate how the main materials are sourced, the contend recyclable material as well as their potential for recycling.

Recycled content

The recycled content is part of the evaluation of the Active House Radar for both new buildings and renovations. In a renovation project it is however only the material that is part of the renovation that is included in the evaluation. In an Active House one should also consider, how the building can be disassembled for recycling and re-use after its end of life. These considerations are part of the qualitative criteria under Disassembly.

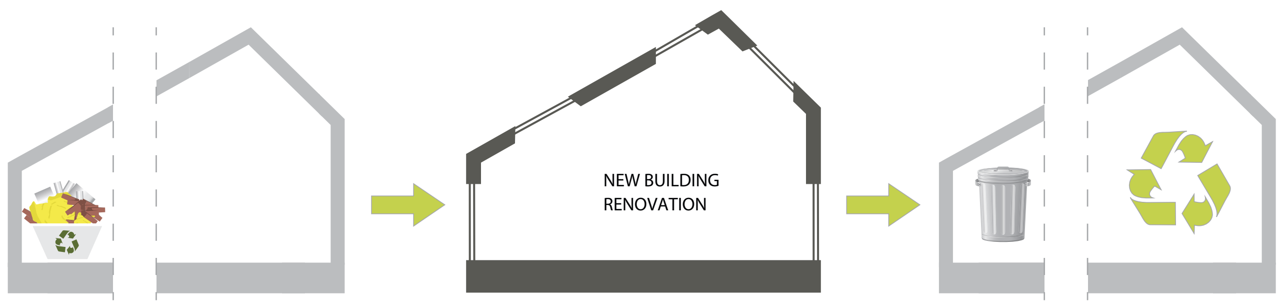


Figure 22: Re-use and re-cycle materials

In the Active House Specification one should evaluate the weighted average of recycled content for all building materials, when taken into consideration 80% of the weight of the building.
The recycled content is the proportion, by mass, of recycled material in a product or the re-use of a product. Recycled material is waste material that has been reprocessed into a final product or into a component for incorporation into a final product. It can either be for the original purpose of for other purposes , whereas re-use means a product or component that is not waste, but which is used again without reprocessing .

When designing an Active House focussing on the recyclable content, it is important to focus on the materials that matters the most. Start by listing the most significant material by weight to get an understanding of which materials to focus on.

The degree of recycled material used in the building can be increased by re-using materials from other buildings or by sourcing materials that contains high degrees of recycled materials. During the sourcing process, investigate if re-used components can be used and ask suppliers to inform about recycled materials in the products.

Identify the top materials by weight and get an understanding of which elements that needs to be assessed to reach 80% og the weight of the building materials.

1

Rank the materials used in the building, by weight.
Focus on the most significant elements e.g.
- Foundation and slabs
- Frame (columns and beams)
- Wall (internal)
- Facade (external)
- Roof.

2

3

Investigate if any of these can come from re-use of existing products or components.

4

Seek information from potential suppliers about the percentage of recycled materials in their products.

5

Calculate the preliminary percentage of recycled content.

6

Adjust the plan of the building, detail the components used and select the right suppliers to reach the level of ambition, which is aimed for.

Example of the calculation of the recycled content of a fictive building

Building part	Product level	Weight (kg)	Recycled content (%)	Recycled content (kg)	Accounting for the weight of the materials – Accululated weight%
Foundation and Slabs	Aggregate – Recycled concrete	1700	100%	1700	21%
Facade (external)	Brick cladding	300	80%	240	25%
Roof	Slate	200	80%	160	28%
Foundation and Slabs	Concrete	3500	5%	175	71%
Beams and columns	Wood	500	10%	50	78%
Wall (internal)	Gypsum	200	25%	50	80%
Door and windows	Glass	400	5%	20	85%
Other materials	Other materials	1200	0%	0	100%

Accounting for 80% of the weight of the building.

Total weight of materials (kg	8000
Weight of 80% of materials (kg)	6400
Weight of recycled materials (kg)	2375
Recycled contend of the 80% of the materials used	**37%**
Active House Radar score	**2**

Responsible sourcing

Responsible sourcing includes the requirement to use certified sourcing. In the Active House Specification one should evaluate the percentage of wood that is certified as sustainable (e.g. FSC or PEFC) and the percentage of suppliers that have a certified environmental management system (EMS). Like in the criteria for recycled materials, the evaluation should account for 80% of the weight of the materials used in the building.

During the sourcing process, seek materials and products that are certified as sustainable wood. E.g. according to FSC or PEFC but also other initiatives are available in different countries and regions. Certificates of chain of custody for the wood fibres certified as FSC, PEFC or other equivalent means of proof, is accepted as proof of compliance. Start by listing the most significant material by weight to get an understanding of which materials and suppliers to focus on.

Relevant labels to look for when selecting materials are:

- **FSC** The Forest Stewardship Council (FSC) promotes environmentally appropriate, socially beneficial, and economically viable management of the world's forests. The origin of the wood is tracked through all entities along the supply chain. For more information: ic.fsc.org
- **PEFC** The Programme for the Endorsement of Forest Certification (PEFC) promotes Sustainable Forest Management (SFM) through independent third-party certification. www.pefc.org

Other relevant programs exist, e.g. in the United States and Canada:

- American Tree Farm System (ATFS) applicable only in the United States. www.treefarmsystem.org
- Canadian Standards Association's Sustainable Forest Management Standard applicable only in Canada. www.csasfmforests.ca, and
- Sustainable Forestry Initiative (SFI) Program, which is applicable to both the United States and Canada. www.sfiprogram.org.

EMS The environmental management system (EMS) should fulfil similar requirements as described in the international standard, ISO 14001. Possible means of proof include ISO 14001 certificates or equivalent certificates issued by bodies conforming to EU Community law or the relevant European or international standards concerning certification based on environmental management standards.

This International Standard specifies requirements for an environmental management system to enable an organisation to develop and implement a policy and objectives, which take into account legal requirements and information about significant environmental aspects. For more information: www.iso.org and www.epa.gov

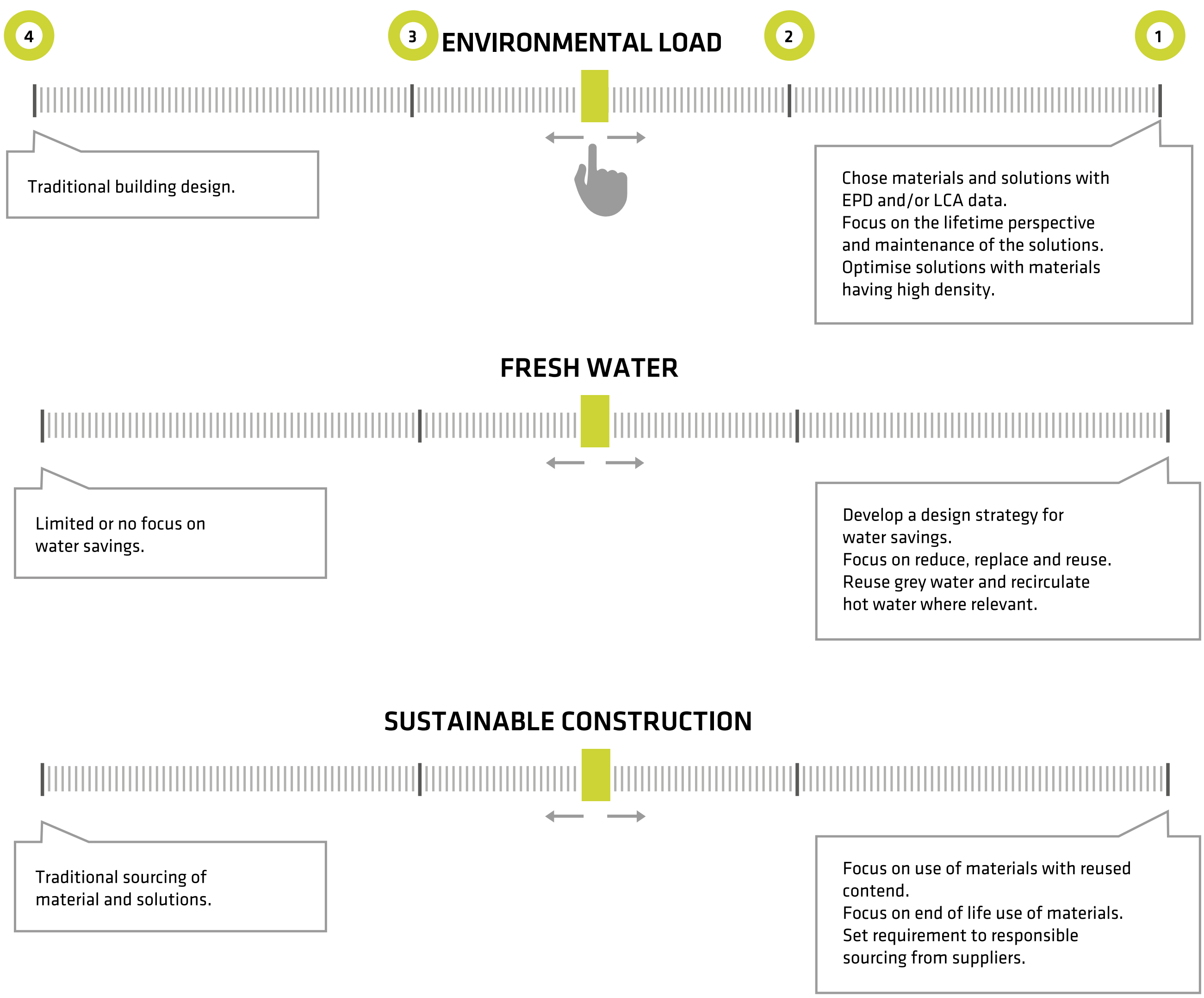
Strategy for disassembly

- Use high-quality reused materials that encourage the markets for the reclamation of materials.
- Minimise the different types of materials which reduces the complexity and number of separation processes.
- Avoid toxic and hazardous materials that increase potential human and environmental health impacts, and potential future handling cost, liability risk and technical difficulties.
- Avoid composite materials, and make inseparable products from the same material that are then easier to recycle.
- Avoid secondary finishes to materials which may cover connections, making it more difficult to find the connection points.
- Provide standard and permanent identification materials chemistry
- Minimise the number of different types of components to increase the quantities of similar recoverable components.
- Separate the structure from the cladding to allow for increased adaptability and separation of non-structural deconstruction from structural deconstruction.
- Provide adequate tolerances to allow for disassembly in order to minimise the need for destructive methods that will impact adjacent components.
- Minimise numbers of fasteners and connectors to increase speed of disassembly.
- Design joints and connectors to withstand repeated assembly and disassembly to allow for adaptation and for the connectors to be reused.
- Allow for parallel disassembly to decrease the time on-site in the disassembly process
- Use a standard structural grid to allow for standard sizes of recoverable materials.
- Use prefabricated subassemblies which may be disassembled for reuse as modular units, or for efficient further separation off-site
- Use lightweight materials and components that are more readily handled by human labor or smaller equipment.
- Identify point of disassembly permanently to reduce the time in planning the disassembly process.
- Provide spare parts and storage for them to allow for ease of adaptation and reuse of a whole component when only a sub-component part is damaged.
- Design foundations to allow for potential vertical expansions of the building in lieu of demolition.
- Use a structural grid as wide as possible to maximise the non-structural wall elements.
- Consolidate mechanical, electrical and plumbing (MEP) systems into core units to minimise runs and hence unnecessary entanglement.

How to optimise an Active House

Environment

Below an illustration for optimisation of an Active House within Comfort and its 3 sub parameters.



Own notes on Environment

Active House Radar

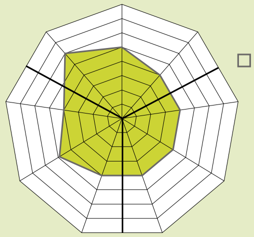
The Active House Radar brings together the three main Active House criteria and describes for each criterion the level of ambition of how 'active' the building has become.

Calculation
The performance of the building has to be calculated for each of the nine sub parameters, following the methodology described in the Active House Specification. The calculation can be made using the Active House calculation tool, available for members of the alliance, or alternatively by using national methods or other standard calculation tools that incorporate the parameters described earlier.

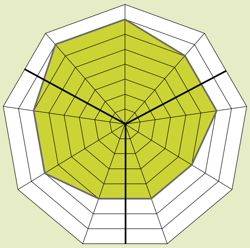
Requirement
For a building to be considered as an Active House, the level of ambition can be quantified into four levels for each parameter, where 1 is the highest level and 4 is the lowest. The ambitious requirement for Active House includes all nine parameters and requires at minimum the lowest level for each of them.

Radar plot
The radar will be automatically drawn when using the Active House calculation tool. For other solutions, it can be designed with the Active House Radar tool on the www.activehouse.info where the specific calculated values for an Active House can be included.

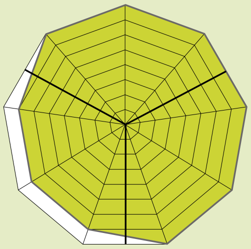
Good



Better



Best

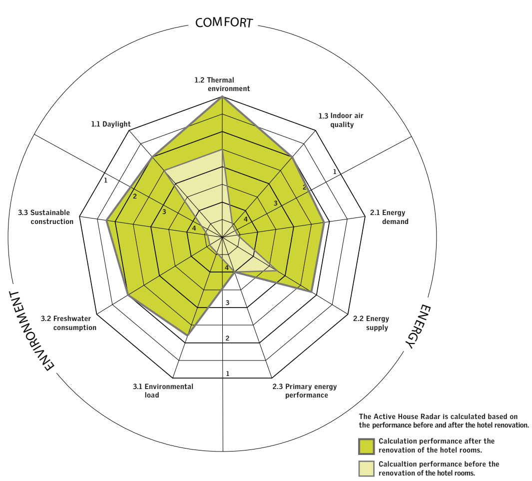


Use of the radar during design process

The radar can be used as a tool for dialogue between the client and the designers, where the requirements and specifications for the specific building can be incorporated in the very early design phase.

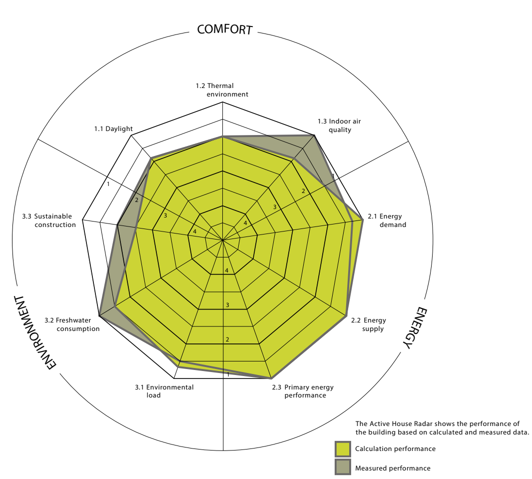
Reference to national standards

The normal reference for a project can be based on the minimum requirement in the building legislation and national standards. It can be valuable to plot those into the Active House Radar in order to show the better performance of an Active House project compared to the national standards.



Renovation and modernization

When a building is being renovated or modernized, the Active House Radar can be used to compare the performance of the existing building with the performance for the modernized building. Thereby the designer can use the radar in dialog with the client in order to optimize the building on individual Active House parameters.



Monitoring of the building during use

The Active House Radar is a good tool for displaying the ambition reached with the building and the calculated values. When the building is inhabited, the radar can be a useful tool for monitoring, evaluating and improving the building. As a communication tool, it can provide clarity as to why the integration of parameters is important for creating Active Houses.

Active House Calculation tool

Use of the tool
The Active House alliance has developed a tool that makes it easy for designers to evaluate and benchmark Active House projects. The tool is based on an Excel platform and can easily be installed and used on a computer. It is a free to use the tool for members of the Active House Alliance, while non-members an use it as a trial version for 30 days. A special student version can be offered for universities and schools for education of architects and engineers.

The tool can be downloaded and installed from the Active House homepage: www.activehouse.info

Calculation with reference values
The tool can be used to make two calculations of the same building.

1. One calculation as the main calculation for the building with input for the specific building being designed.
2. The second calculation to be used as a reference.

This reference value can be based on the national legislation, a reference building with the specific ambition of the investor, an existing building if the project is a renovation project, or it can be monitored values to compare the theoretical performance with the real world experience. Combining both calculations into one sheet or radar gives the designers a communication tool that can be used during the design process, or as a tool for the monitoring of the project.

Input Comfort
A daylight calculation and simulation shall be made for the primary rooms and inserted for each primary room. The lowest value of all rooms will be used for the final evaluation. Second, the daylight availability for the winter period has to be evaluated. The average of both calculations gives the Active House score.

A thermal comfort evaluation of the primary rooms needs to be carried out and evaluated for both summer and winter conditions. The lowest value is used for the evaluation. The thermal comfort can be stated either as the specific level calculated in the Active House tools or it can be the classification in accordance with EN 15251. The average of the summer and winter conditions gives the Active House score.

Air quality is based on CO_2 levels and shall be carried out for primary rooms, with reference to the outdoor level. The lowest value (i.e. the worst condition) is used in the evaluation and used to score the Active House

The Active House alliance has developed a support tool, where the input data for thermal comfort and air quality can be calculated. The basis for the calculation is a simulation of each room according to EN 15251. This tool is available at the Active House homepage.

Input Energy
The energy demand (final energy) is calculated for the whole building, with the energy consumption based on energy source and system (heat pump, boiler, district heating, electricity etc.), including efficiency values (COP) for heat pump. The input data is divided into heating, hot water, ventilation, lighting and technical installations. Based on the input the energy demand is calculated as the final energy and gives the score.

The renewable energy is evaluated for heating and electricity and can be split into the amount of renewable energy installed on the building, used from the district energy system and used from the grid. The unit used is kWh/m2. Based on the input, the percentages of the renewable energy is calculated and used to score the Active House.

The primary energy factor shall be identified for the specific energy source and the result of primary energy is finally calculated based on the above input and used to score the Active House. The calculation follows the principles of the European Directive for Energy Performance of buildings, where renewable energy installed on the building or plot is deducted from the energy demand, before the primary energy is calculated.

Input Environment
The Environmental load includes six sub parameters that have to be calculated and given. Each parameter has to be evaluated for the primary constructions like external wall, roof, slabs and main technical installations. The input follows the European methodologies for LCA evaluation of products and buildings and if a calculation is already made, the data can be used as input. As an alternative the Active House alliance has developed a support tool that can be used. The tool can be used for the primary construction materials and can be downloaded from the homepage. The average value of the six sub parameters is used to score the Active House.

The water consumption has to be calculated and compared with the national averages. The percentages between the two are used as input and are used to score the Active House.

The data for sustainable construction includes calculations of the share of reused materials in products used, as well as the share of material that can be reused after demolishing. The calculation should include the main materials. Supplementary to the above, the sourcing of materials is evaluated, with the percentages of wood from FSC or PEFC sources, and the percentages of materials covered by EMS systems that have to be stated. The averages of the above are used to score the Active House.

Output and print
The tool include two output possibilities:
1. A simple one page document with radar and the specific values for the main calculation and a reference building can be established as a PDF document.
2. A detailed report with the specific values and input for the whole calculation can be made as a PDF document. This document is valuable for detailed follow up and dialog on topics that can be optimised.

Active House Cases

The Active House methodology has been used to evaluate different projects throughout the world. As an inspiration on how the vision can be used for homes, offices, new build and modernisation, nine projects from Canada, Norway, Denmark, Netherlands, Germany, France, Italy and Austria has been chosen.

New build homes
- Great Gulf Home – Canada
- Healthy home town houses – Norway
- Maison Air et Lumiere – France
- Rhome – Italy (Solar Decathlon winner 2014)

Modernisation of Offices:
- Green Solution House – Denmark
- ROCKWOOL International Center 2 – Denmark

Modernisation of homes
- LichtAktiv Haus – Germany
- De Poorters van Montfoort – Netherlands
- Garden of VENUS - Austria

See more projects at www.activehouse.info, where you are also invited to upload your specific project.

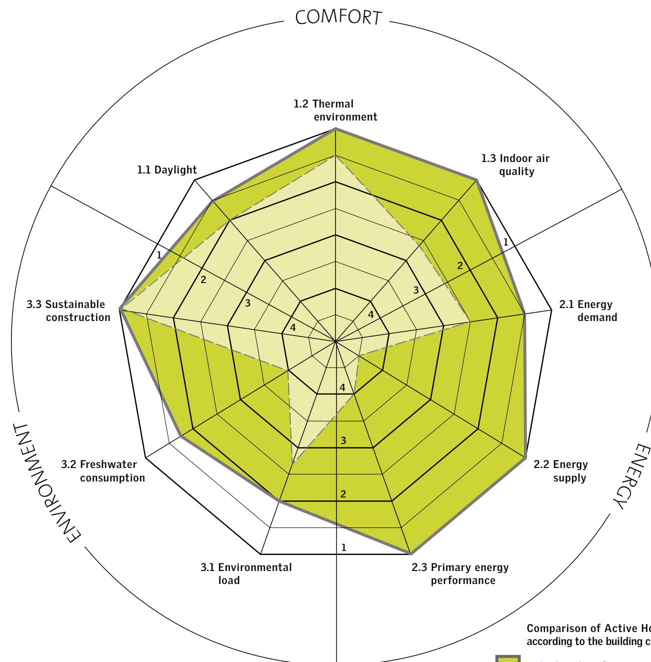
activehouse.info
BUILDINGS THAT GIVE MORE THAN THEY TAKE

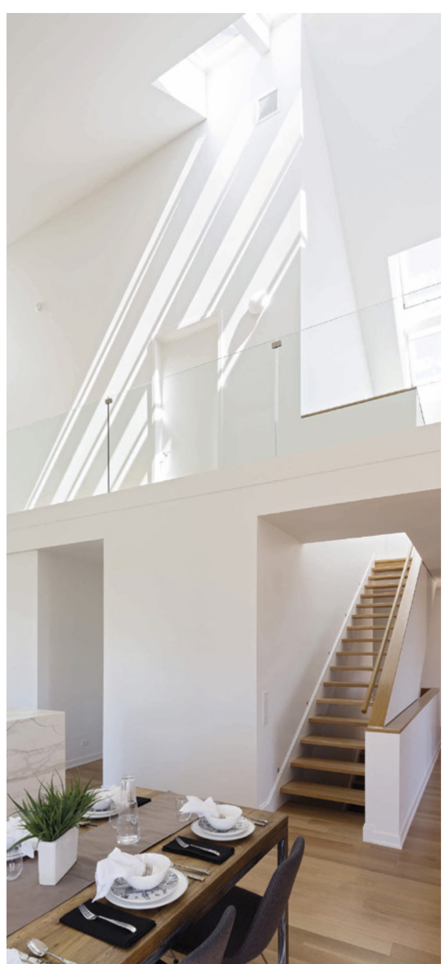
Great Gulf Home

– first Active House in Canada

Developer: Great Gulf
Architect: Superkül inc Architects
Location: Thorold, Ontario, Canada

The first Active House in Canada was designed using the Active House guidelines to develop and optimise the building. The house has a traditional gabled roof, where the designers has created a multifunctional solution with double-height space. The home offers excellent daylight conditions and natural ventilation, creating a comfortable indoor environment.





Photos by: Torben Eskerod

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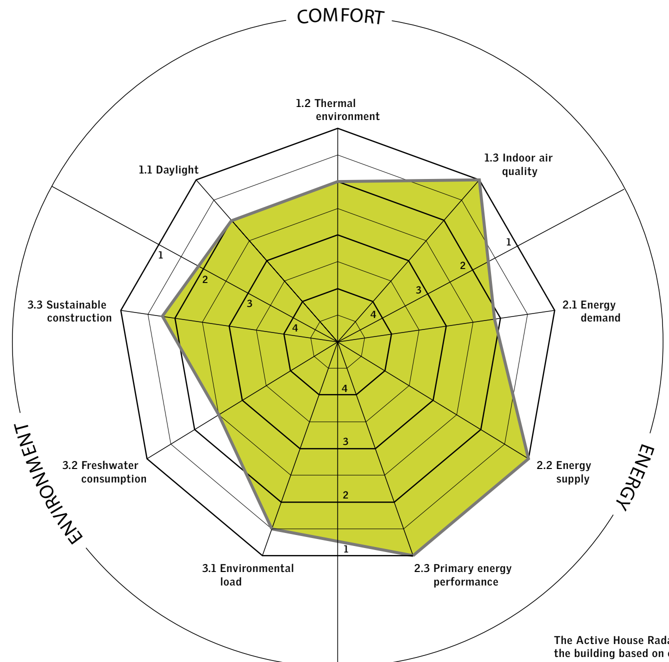
BUILDINGS THAT GIVE MORE THAN THEY TAKE

Healthy Home Townhouses

– Active House settlement in Stjørdal, Norway



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

Calculation performance

Developer: Fremtidens Aktivhus, established by Tore Ligaard AS.
Architect: Ketil Skogholt tegnestue
Location: Sjørdal, Norway

Healthy Home Townhouses in Stjørdal, Norway were designed and built as homes that offer beautiful design, a healthy indoor environment and minimal energy consumption. By combining the Active House principles with local expertise and experience, Healthy Home Townhouses can be offered at a price far lower than most en-ergy- efficient constructions in the local market.

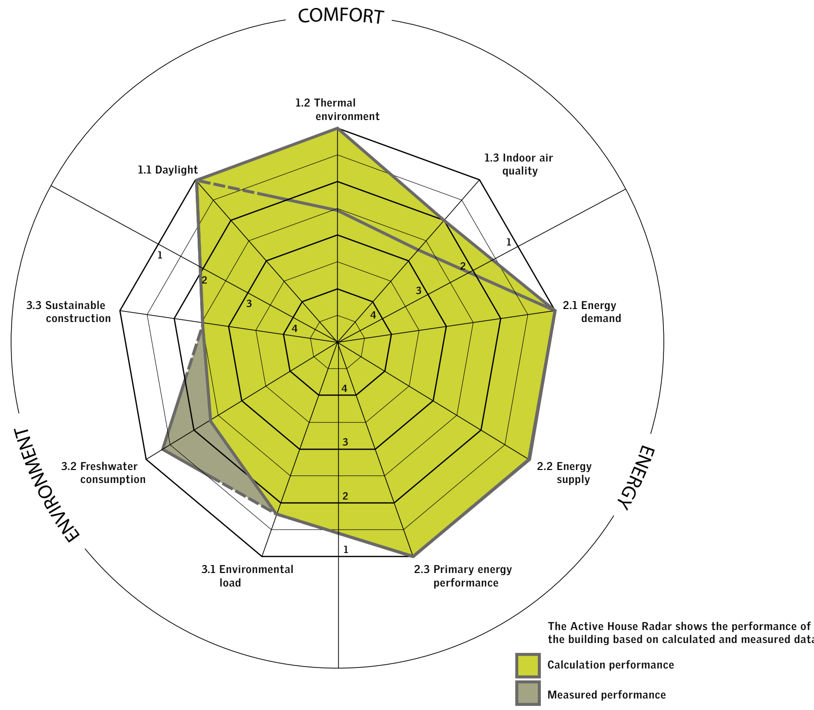
Photos by: Anniken Zahl Furunes.

Maison Air et Lumière

– meeting future demands with existing technology

Developer: the VELUX Group
Architect: Nomada Architects
Location: Verrières-le-Buisson, France

The vision has been to build a detached house without any environmental impact focusing on the living conditions of the residents. The modular design can be replicated to suit other contexts, including single family homes and terraced or urban houses.



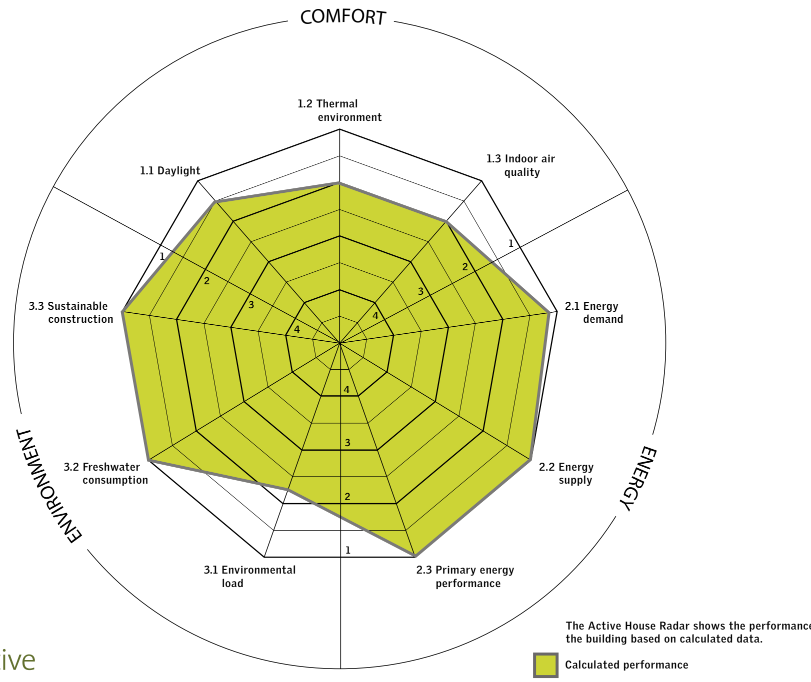
The Active House Radar shows the performance of the building based on calculated and measured data.

Photos by: VELUX A/S

RhOME

– a home for Rome

Developer: UNIVERSITY OF ROMA TRE
Department of Architecture, Italy
Architect: Designed by students from the university in 2014
Location: Participated in Solar Decathlon 2014 in Paris



The RhOME project was the winner of the Solar Decathlon competition in Paris 2014. It was designed as a modernisation case and a roof-top renovation project. The intention was to describe architectural features and technological innovations in a roof-top renovation that could not be obtained in a common floor or in the ground floor. The project was designed based on the Active House criterias, optimising thermal and luminous comfort and at the same time minimising energy consumption.

Photos by: Lorenzo Procaccini

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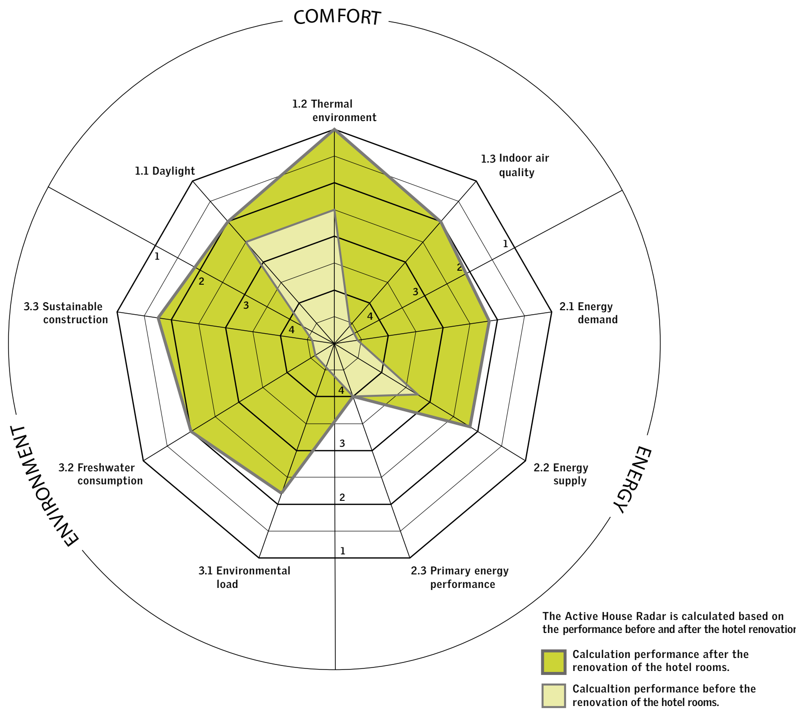
BUILDINGS THAT GIVE MORE THAN THEY TAKE

Green Solution House

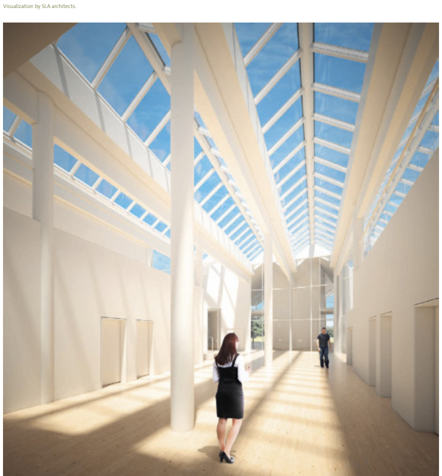
– exploring circular sustainability

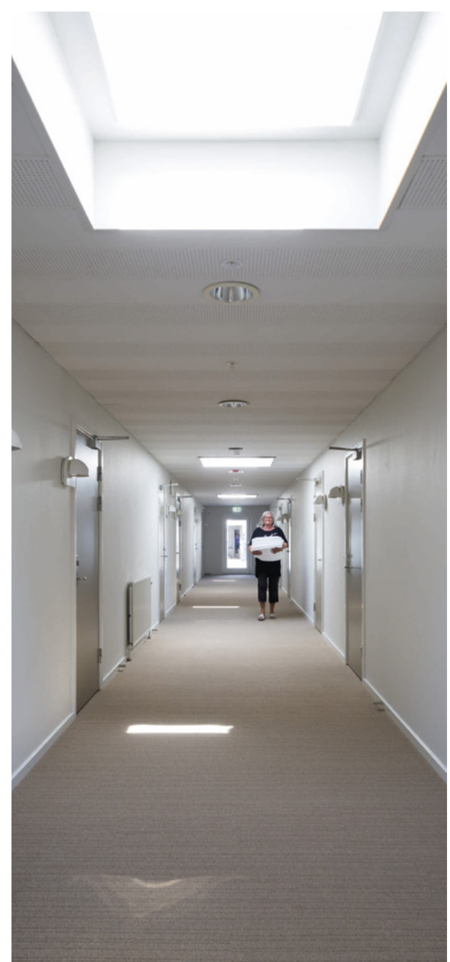


Developer: Hotel Ryttergaarden
Designer: GXN Innovation. 3XN Architects
Location: Rønne, Denmark

Green Solution House is a sustainable knowledge and conference centre combined with hotel accommodation. Visitors will be inspired to make sustainability a part of their daily life and work.
The design of the building itself shows a holistic approach to sustainability, emphasising circular solutions including good indoor climate, renewable energy sources and healthy recyclable materials, exploring circular sustainable solutions of tomorrow – today!

Visualization by SLA architects.





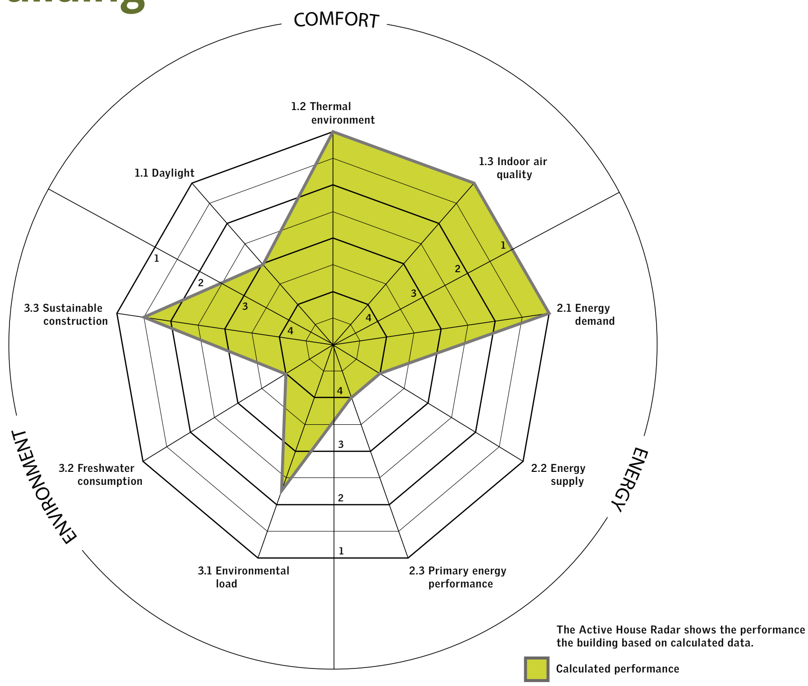
Photos by: Torben Eskerod

ROCKWOOL International Center 2

– renovation of an office building

Owner: ROCKWOOL International A/S
Architect: Vandkunsten A/S
Engineer: MOE A/S
Location: Hedehusene, Denmark

The office building was established in 1979 in accordance with the energy standards from that period so there was a need for general modernisation and upgrade. The total modernisation and energy renovation of the 3600 m² office building has reduced the energy demand with 85% and upgraded the building to a level equal to the Danish energy class 2015 (38.5 kWh/m²/year).



Photos by: ROCKWOOL International A/S

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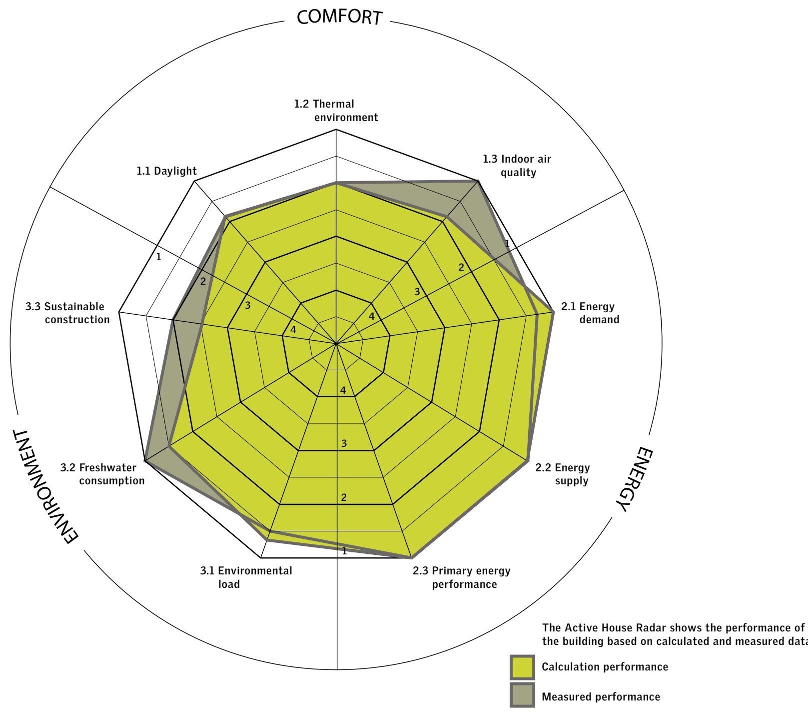
BUILDINGS THAT GIVE MORE THAN THEY TAKE

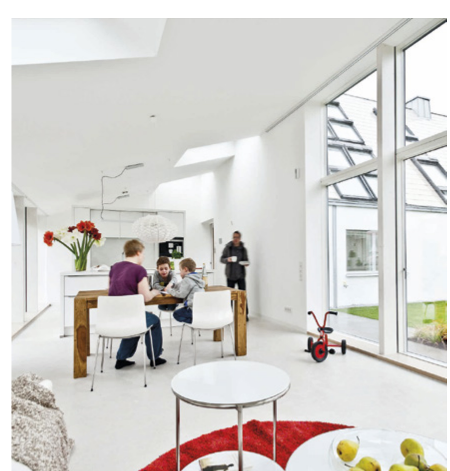
LichtAktiv Haus

– modernisation of a 1950 settler house

Developer: the VELUX Group
Architects: Katharina Fey (concept), Prof. Manfred Hegger and Tim Bialucha TU Darmstadt ee (design)
Location: Hamburg, Germany

The modernisation of the 1950 settler house in Wilhelmsburg realises the vision of combining daylight and natural ventilation to create comfortable indoor climate. It has proven how energy efficiency can be combined with the highest standards for livability in homes that operate on a CO2 neutral basis.





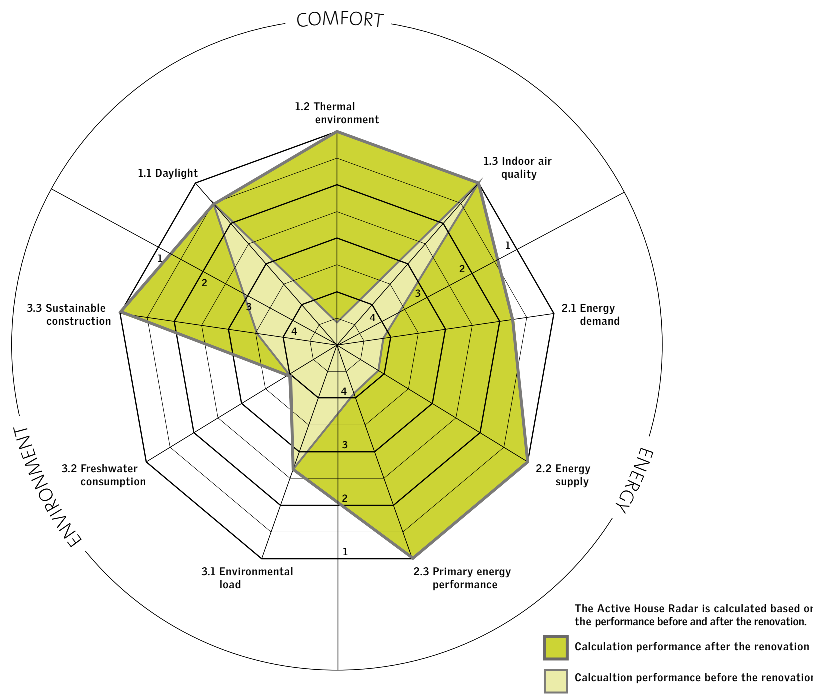
Photos by: Adam Mørk

De Poorters van Montfoort

– renovation of existing social housing into Active House

Developer: GroenWest
Architect: BouwhulpGroep
Location: De Poorters van Montfoort, the Netherlands

The owner, housing association GroenWest, decided to embark on a major renovation of the social housing.
The remodelling of De Poorters van Montfoort has revitalised the buildings and the indoor conditions into a modern design meeting the future ambitions for comfort and energy in new buildings, based on the active house vision.



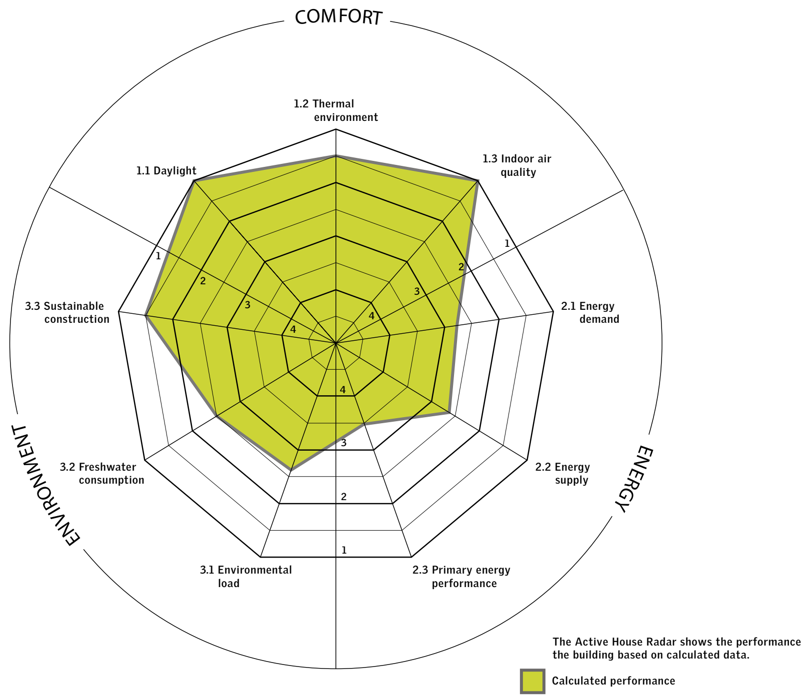
Photos by: Torben Eskerod

House by the Garden of Venus

– Active House renovation of a "House on a House" concept

Owner: Stefan Schauer
Architects: Volker Dienst and Christoph Feldbacher
Location: Willendorf, Austria

A unique and exemplary Active House renovation to extend a historical building led to a "House on a House" concept. The building, is an architectural gem with the walls, ceilings and furniture conflating into a harmonious entity. Owing to the lightweight construction of the new extension, which is made entirely of local wood, more than 75% of the building can be recycled at the end of its lifespan.



Photos by: Jörg Seller, architectural photography

Acknowledgements

These guidelines are developed by the Active House Alliance in an open source structure, where the individual members have contributed with experience on design of Active House projects as well as with specific competences within relevant topics. The guidelines has been discussed at a work group meeting taking place in Brussels during the European Sustainable Energy Week 23-27 June 2014 and at an Active House Workshop on 19 November 2014 in Budapest.

A special thanks to the below people and organizations for contributing to the guidelines

Comfort
- Nicolas Roy, VELUX A/S
- Ariane Schumacher, Saint-Gobain Glass
- Yves Lambert, RENSON
- Thorbjørn Færing Asmussen, VELUX A/S
- Istvan Kistelegdi, University of Pécs
- Emmanuel Valentin, Saint-Gobain Glass

Energy
- Connie Enghus, ROCKWOOL International A/S
- Emilia Cerna Mladin, University Politehnica of Bucharest
- Carsten Rode, Technical University of Denmark
- Kurt Emil Eriksen, VELUX A/S
- Susanne Dyrbøl, ROCKWOOL International A/S
- Sebas Veldhuisen, ROCKWOOL International A/S
- Arianna Brambilla, Politecnico di Milano
- Alexander Kucheravy, Architect, Belarus
- Morten Birkved, Technical University of Denmark
- Carsten Østergaard Pedersen, Grundfos Holding A/S

Environment
- Karin Schjødt Nielsen, Grundfos Holding A/S
- Mikkel Skott Olsen, VELUX A/S
- Henrik Kjeldgaard, Grundfos Holding A/S
- Lone Feifer, VELUX A/S

Workshops
- Bruxelles on 23.6.2014 organized by Bas Hasselaar, SBRCURnet and the Active House Alliance
- Budapest on 19.11.2014 organized by Monika Tornóczky, Hungary Green Building Council and Zsolt Gunther, 3h architects.

Executive editor
- Bas Hasselaar - SBRCURnet

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If you wish to contribute to the development of the alliance and to become a member, please contact the secretariat for further information and membership fees.

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