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BENCHMARK AND REQUIREMENT TO COMFORT LEVELS BY USE OF ACTIVE HOUSE TOOLS

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SUMMARY

Design of sustainable buildings needs a holistic approach where all crucial aspects are taken into consideration in the early design process. Energy efficiency is one of the main issues discussed for sustainable buildings today and needs to be evaluated. However as people spend up to 80-90% of their time inside buildings, it is imperative that the development of sustainable buildings also has a strong focus on the indoor comfort and human health aspects. In addition, it's important for sustainable buildings to consider their impact on key environmental issues and reduce their carbon footprint,

The Active House Vision adopts this holistic approach with a balanced focus between the comfort, energy and environmental aspects of residential buildings. The paper discuss the need for this holistic approach and will present a number of design aspects from existing projects based on the Active House Guidelines within Comfort, Energy and Environment buildings.

The guidelines give specific focus on the design process and examples on how the daylight conditions can be optimized in buildings and how indoor climate can be optimized in warm climates using passive technologies, shading etc.

INTRODUCTION

People spend up to 90% of their time inside buildings and therefor the design of buildings should take its starting point in how the building are designed for people to live and work in them. Due to climate changes and lack of resources, the focus on the design has moved to an energy efficiency focus, with limited focus on health and comfort in buildings.

Learnings from the oil crises in the 70 has shown that a single focus on reduction of energy can create buildings that has limited indoor climate conditions. Up to 30% of the buildings are not creating a good indoor climate for people and suffer from the "sick building syndrome".

This need to be focused on in order to develop buildings that are healthy comfortable and environmental friendly for people to live and work in. Active House is one of more solutions that consider this. Active House is a vision of buildings that create healthier and more comfortable lives for their occupants without impacting negatively on the climate, by focusing on holistic design of buildings with a balanced evaluation of Comfort, Energy and Environment



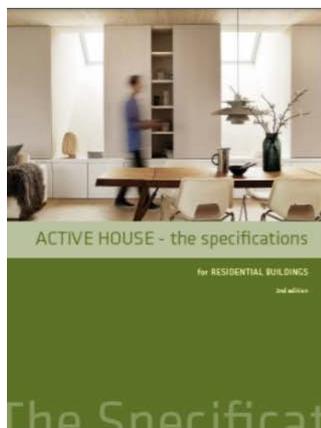
Figure 1 Active House principles

RATING AND EVALUATION

An Active house can be developed and evaluated based on the Active House Specification, which all together evaluate buildings from 9 quantitative parameters, which can be rated from 1, which is the best score to 4 which is an acceptable score.

The rating is chosen in accordance with the requirement for the specific parameter. As an example, the parameter “Annual primary energy” require a level of maximum 0 kWh/m² which is a fully zero energy house, whereas class 2 require a primary energy level below 15 kWh/m², level 3 a level below 30 kWh/m² and level 4 is with a primary energy level above 30 kWh/m².

Based on the score the Active House radar can be developed and it will give a quick overview on how the building perform on all 9 parameters.



- Comfort
 - Daylight
 - Thermal environment
 - Indoor air quality
- Energy
 - Energy demand
 - Energy supply
 - Energy performance
- Environment
 - Environmental loads
 - Freshwater consumption
 - Sustainable construction

Evaluation of each quantitative criteria give a rating from 1 (best) to 4 (acceptable)



Figure 2 Specifications, sub parameters and radar tool for Active House

DESIGN GUIDELINE

In order to optimize the conceptual development of Active House and to help architects and engineers to prepare for a later evaluation of the project, a conceptual design guide has been developed. It focuses on each of the 3 main criteria Comfort, Energy and Environment, and take into consideration topics that should be evaluated in the very early design phase of an Active House.

These guidelines lay down the key principles influencing the performance of an Active House and create the platform for a later evaluation, based on the Active House Specifications and the Active House Radar

Guideline structure

The guidelines are divided into 4 chapters giving guidance to each of the 3 parameters Comfort, Energy, Environment, as well as the use of the Active House radar. The individual chapters give recommendations and rules of thumbs for the conceptual design as well as it describes factors that influence the performance of the individual parameters.

In the following, the paper discusses the chapter about Comfort and brings forward examples on how the guidelines focus on the optimization of the daylight design of the building. There is a similar structure for the other 8 quantitative parameters.

Comfort design

People spend the most part of their time living indoors, at home and at the workplace, as well as during leisure activities. The Active House guidelines promote solutions for people to live in comfortable indoor environments designed for human needs. After all, it's important not to forget that the primary function of residential buildings is to provide safe and enjoyable living environments for its inhabitants, aspects that can never be compromised at any costs. An Active House shall therefore be evaluated on the 3 quantitative comfort topics: daylight, thermal comfort and air quality.

Daylight conditions are an important aspect of the comfort in an active house, and has a strong effect on our wellbeing. Findings in the field of lighting research have revealed that the quantity and quality of light received by our eyes does not only affect our vision, but 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 is part of a vital survival behaviour. If the thermal environment does not meet the expectations, the building occupants will try to influence the thermal environment to make it meet their expectations, i.e. by installing local electrical heating or cooling units. Equipment using additional energy can be avoided if the buildings are designed with thermal comfort in mind from the beginning. In hot conditions, thermal comfort is adaptable for humans and limits for acceptable indoor temperatures for naturally ventilated buildings are higher than for mechanically ventilated buildings due to people's behaviour. Due to the importance of human behaviour and due to energy efficiency, thermal comfort is included in the Active House requirement.

In addition to light, indoor air quality is a crucial factor in achieving healthy indoor environments where the amount of air people breathe per day reaches 12,000 litres as people spend up to 90% of our time indoors, the air people breathe comes from indoor environments. Active House reflects those needs by setting ambitious requirements to the indoor air quality.

Daylight guidance

Daylight has been utilized as the primary source of light in buildings for centuries, but the benefits associated with daylight go beyond human needs for vision, as daylight is also a vital part of humans psychological and physical health. Exposure to high levels of daylight during daytime, and darkness at night time, has influence on the entrainment and regulation of peoples circadian system by the regulation of hormones influencing our sleep/wake cycles, mood, productivity, alertness and general wellbeing.

To this effect, it's important to note that while some electrical 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 figures below show a comparison between the spectrum of daylight (left) and of a fluorescent lamp (right), with daylight overlaid with a yellow line. This is a good example showing how rich daylight is in all areas of the spectrum when compared to electrical light sources.

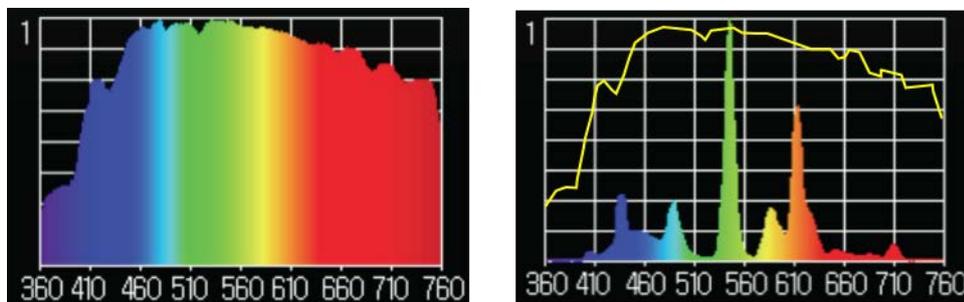


Figure 3 Light spectrum for Daylight and Electrical light

With this in mind, buildings should be designed to optimize the daylight conditions. The traditional requirements for daylight in residential buildings have in the past been based on simple rules of thumbs such a glazing-to-floor ratio demand of 1:10. Such requirements cannot ensure that daylight is either sufficient or correctly distributed in a room, and cannot serve as a valid method to achieve daylight quality in buildings.

Daylight factor

The use of validated computer simulation tools for daylight calculations allow to evaluate both the quantity and distribution of daylight in a room, while taking into account influential parameters such as window placement, obstruction and glazing transmittance.

Daylight conditions in Active House projects are evaluated with daylight factor simulations. By definition, the daylight factor is the illuminance on a surface expressed as a percentage of the external diffuse illuminance. 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.

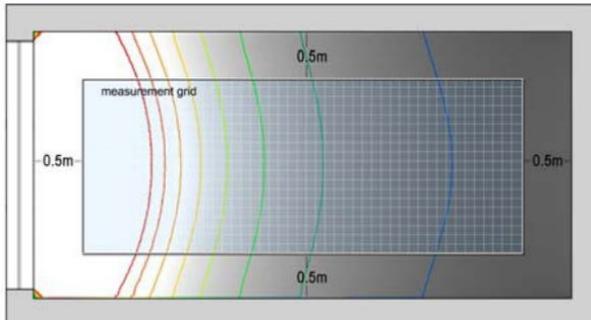


Figure 4 Daylight factor calculation

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

In an Active House it is important that the building allows for optimal daylight. Electric lighting during daytime should rarely be necessary, which should make it possible to reduce the overall energy consumption for lighting. An average daylight factor of 5% will ensure that a room appear substantially daylight and this is the best Active House rating class (level 1) whereas an average daylight factor of 2% will provide only a modest amount of daylight and electrical lighting is likely to be frequently used, giving a rating of 3 in the Active House rating.

Daylight factor simulations allow to take into account all factors that will impact the availability and distribution of diffuse daylight in a room. It's important to have good expertise with the simulation tool used in calculations and to take into account the detailed window/room/building geometry, obstruction from landscape, glazing transmittance and surface reflectance of inner walls as those parameters can drastically impact the results accuracy.

The quality of direct sunlight into buildings has a positive effect on people and create an interaction between inside and outside of buildings. Therefore the direct sunlight has to be taken into consideration in the very early concept phase. Minimum one of the main habitable rooms has to be evaluated and it must be evaluated if and how surrounding buildings effect the sunlight between autumn and spring equinox. This is evaluated at the same level as the daylight factors and to reach the best level the main habitable room should be provided with sunlight access in at least 10% of probable sunlight hours.

In addition to the quality of daylight as a light source, the quality of view to the outside environment is an important aspect linked the experience of daylight in a room. Studies have shown that people invariably prefer daylight as a light source, and a room with a view to the outside environment and nature. This is however not a part of the quantitative requirement to an active house, but a qualitative requirement that is recommended to include in the evaluation.

How to design optimally for daylight

The following is a list of key elements to consider for succesful daylighting design in residential buildings.

- The building design should make sure to provide the following fundamental needs:
 - 24-hour cycle of illumination with period of darkness and of bright light
 - Chance for exposure to bright levels of daylight and sunlight during the winter months
 - Contact to the outside world and nature
 - Avoid glare and visual discomfort
- The use of multiple windows with different orientations can provide a better distribution of daylight in a room, and allow to keep unobstructed view when shading is needed to control sunlight penetration.
- The house design should allow for penetration of sunlight deep into the rooms during daytime hours in the winter period.
- 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.
- Roof window and skylights can be used to deliver daylight and sunlight deep into rooms, and rooms facing north.
- Highly reflecting light tubes can be used to deliver sunlight and daylight into windowless spaces.
- Shading devices should be used to control visual comfort and privacy in rooms where it is needed.
- Black-out blinds should be used in bedrooms to provide darkness during sleeping hours.
- The type of window glass should be selected based on:
 - Its thermal and energy balance performance; considering both solar gains (g-value) and heat loss (U-value)
 - Its light transmittance properties (LT%); the higher the better
 - Its spectral quality, the more neutral the better to keep the quality of daylight and high colour rendering index
- Consider orientation for the placement of windows, selection of glazing and shading strategy.
 - North facing roofs and facades are exposed to diffuse daylight, except for roof windows with low roof pitch.
 - South facing roofs and facades are exposed to diffuse daylight and strong direct sunlight with high solar angles.
 - East and West facing roofs and facades are exposed to diffuse daylight and direct sunlight with low solar angles.
- Glare from direct sunlight reflections and high luminous contrast between surfaces should be possible to avoid with shading devices controlling the amount of light in the rooms. Attention should also be paid so that the shading device used don't become a source of glare, e.g. a white fabric receiving sunlight can become extremely bright and cause glare.
- 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.

Using the above simple guidelines in the very early conceptual design phase will prepare the building for a later daylight evaluation, however it can not replace a detailed calculation, which is necessary in the following design processes.

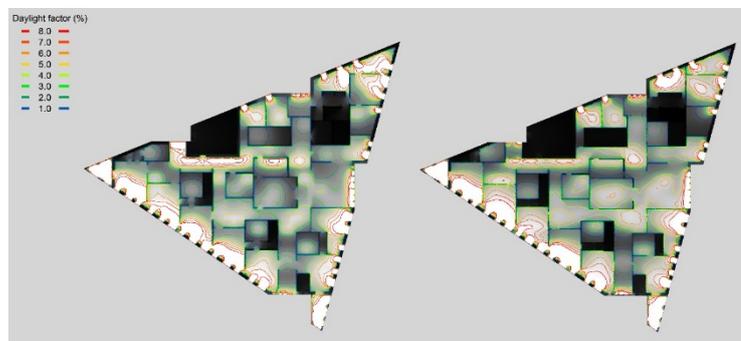
SOLHUSET A CASE BASED ON ACTIVE HOUSE VISION

Solhuset (Sunhouse) is a 1300 m² integrated childcare centre with 100 children and 30 employees. The vision was to set new standards for future sustainable childcare centers. It rests on the Active House principles of buildings that give more than they take – to the children, adults, environment, and surroundings. The learnings and experience from the design of Solhuset is reflected in the guidelines.

Solhuset has been designed with high ambitions to create a healthy and comfortable indoor climate with plenty of daylight and access to fresh air. It has high-ceilinged rooms and strategically placed windows to ensure optimum use of daylight.

The daylight conditions shown to the right (fig 5) has been evaluated with daylight simulation tools as recommended in the Active House Guidelines.

The first evaluation of the daylight conditions was based on the original design from the architect team. It showed that



even though the design had focused on daylight there were possibilities to improve the quality and distribution of daylight in specific key rooms of the project, such as the gymnasium and common room used during the lunch hours, which did not meet the highest demands in the Active House specifications. (see left picture above)

The revised design included a new strategic position of the windows, which were optimized based on simulation results from the calculation tool. In addition, the internal window linings were also optimized to allow more daylight in the rooms and achieve a better distribution. By the use of a validated daylight simulation tools, the building has thereby reached a daylight factor of 7% in living rooms and up to 4% in the innermost part of the rooms.

The better distribution of daylight in the building has been reached with the same amount of windows as used in the first evaluation, so the better daylight conditions is established without use of more windows. The window area is 28% of the floor area.

CONCLUSION AND NEXT STEPS

The general conclusion of this paper is that the future sustainable buildings can be built with the technology available already today, however the main challenges is to optimize the design with the available technologies and for this purpose, a further development of good recommendations and guidelines can be a valuable tool.

It is also in the very early design phase that the majority of the energy efficient and indoor comfort requirements are taken, and if they are not correct, they are relatively costly and difficult to change in the later stage of the project. Also in this sense good recommendations and guidance is needed.

Already today several good guidelines for sustainable buildings exist, like LEED, BREAM and DGNB and those are valuable to use, however the challenge is that they include more than 50 different parameters, which seen from a cost perspective can be difficult to evaluate in projects with limited resources, like small buildings, single family homes etc. for small buildings.

Another issue is a lack of knowledge sharing in the construction sector where there is a need for a stronger and knowledge sharing in the whole sector from manufacturers to architects, engineers and house owners. Such knowledge sharing can be strengthened by use of common tools and a follow up and reporting on the outcome of the design.

The Active House guidelines deliver an answer on all 4 topics mentioned above and as it is limited to 9 parameters it is possible to integrate it into projects with limited resources and time. The next steps with the guidelines is to test them at a number of projects throughout the world and to update them with the knowledge sharing and learnings from those projects.