activehouse

THE ACTIVE HOUSE SPECIFICATIONS

3rd EDITION

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Front page: *Active House Centennial Park, Canada.*
Photo: *Igor Yu.*

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Index - Specifications

Active House Centennial Park, Canada.
Photo: *Igor Yu.*

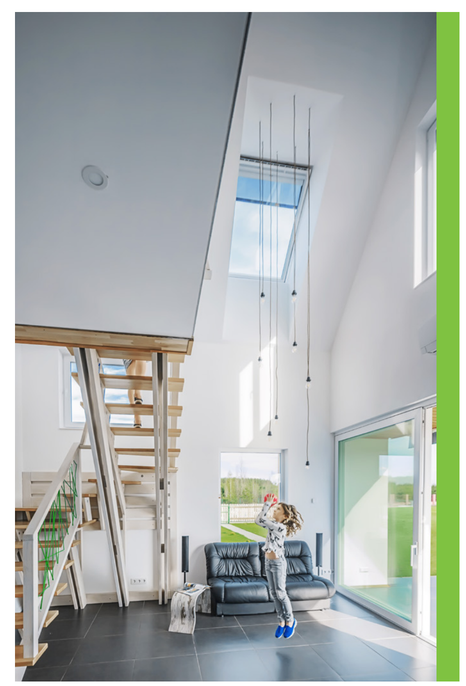
Introduction

We live in a world where the impact of humanity on the environment is becoming increasingly apparent. We no longer talk of climate change and global warming, but of climate crisis and global heating. At the same time, resources are becoming scarce and more and more focus is coming on healthy living. With buildings responsible for approximately 40% of the worldwide energy consumption, attention should be given to the effect a building has on its surroundings.

The impact the built environment has on people is enormous. In developed countries, most people spent the vast majority of their life indoors. There is a need for buildings that offer a healthy indoor climate, where people can live, work and play, to be able to develop themselves to their full potential without being inhibited by the building's indoor environment. At the same time, these building should not place a negative impact on the environment, locally or globally. Active House aims to cater to those needs, by creating healthy buildings for people and planet.

This publication – the Active House Specifications – outlines the specifications for designing an Active House, a home, school, office, or other type of building that integrates health and comfort with energy efficiency and environmental performance. It can be used in combination with the Active House Guidelines to help people get an understanding of the vision and principles of an Active House, and how to apply them to new designs or renovations. The Active House Specifications explain the vision that is Active House and outline the technical specifications that determine the quality and performance of an Active House.

Optimahouse, Ukraine.
Photo: *Alexander Kucheravy.*



This definition and description of an Active House is intended as a guideline at an international level. It seeks innovative technical approaches whilst introducing goals of architectural quality and environmental design, at the same time as providing energy efficiency. These specifications are generic, but initially developed with residential buildings in mind. They are applicable to other building types as well, in which case some interpretation of values may be required to keep in line with the Active House vision, but cater for specific needs.

Living, working or learning in a building designed according to the Active House principles should be a step forward and not present any obstacles for the occupants, whether they be children, their parents or grandparents, or people with special needs and physical challenges.

Active House is a vision of how to create sustainable buildings anywhere in the world. These Specifications offer insight and knowledge needed to draw up the required technical specifications and design concept for an Active House. They include important issues to consider when creating an Active House. These issues can be qualitative or quantitative. The qualitative aspects describe aspects that influence the quality of a building or how it is being experienced by the user, but difficult to put a number on, such as having a view. The quantitative aspects form the basis for the Active House radar, that can be used as a communication instrument to display the quality of an Active House in an instant. These specifications for building an Active House seek to provide an answer for the three main challenges facing the building industry today: comfort, energy and environment.

This document contains the fully revised and new version of the specifications. The specifications are updated to reflect the current developments in the building industry and to remain at the forefront of sustainable buildings, while still keeping the aspects that make Active House unique.

The specifications are created in cooperation with members of the Active House Alliance, who have shared their knowledge, experiences and feedback on the previous edition of the specifications. They are created using an open source model, online debates and contributions as well as offline meetings and workshops with international participation across the building industry.

Active House enjoys increasing worldwide interest in its vision of buildings that are healthy for both people and planet. With these specifications, together with the Active House Guidelines, we hope to inspire many to design, create, develop and commission buildings that have a positive influence on their surroundings and people who use them.

The Hague, 10 December 2019

Sunlighthouse, Austria.
Photo: *Adam Mørk.*

Vision

CREATING BUILDINGS FOR PEOPLE AND PLANET

Active House is a vision of buildings that create healthier and more comfortable lives for their occupants without impacting negatively on the climate – moving us towards a cleaner, healthier and safer world.

The Active House vision defines highly ambitious long-term goals for the future building stock, as well as the existing building stock through renovation. The purpose of the vision is to unite interested parties based on a balanced and holistic approach to building design and performance, and to facilitate cooperation on such activities as building projects, product development, research initiatives and performance targets that can move us further towards the vision.

The Active House principles propose a target framework for how to design and renovate buildings that contribute positively to human health and well-being by focusing on the indoor and outdoor environment and the use of renewable energy.

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

COMFORT ***– creates a healthier and more comfortable life***
An Active House creates healthier and more comfortable indoor conditions for the occupants, ensuring a generous supply of daylight and fresh air, combined with a comfortable indoor temperature and absence of disturbing noise. Materials used have a neutral and where possible positive, impact on comfort and indoor climate.

ENERGY ***– contributes positively to the energy balance of the building***
An Active House is energy efficient. It utilises smart energy sourcing, energy needed is supplied by renewable energy sources integrated in the building or from the most sustainable source from the nearby collective energy system or electricity grid.

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

LangFang Office, Beijing China.
Photo: *Alexander Kucheravy.*

Active House Solbjerg, Denmark. **Photo:** *Torben Eskerod Photography.*

Active House Radar

SHOW THE AMBITION WITH THE BUILDING

An Active House is the result of efforts to actively integrate the three main principles of Comfort, Energy and Environment in the design of a building and in the finished building.

The Active House Radar shows the level of ambition of each of the three main Active House principles, containing four criteria for Comfort, three for Energy, and two for Environment.

The integration of each principle describes the level of ambition of how 'active' the building has become. For a building to be considered as an Active House, the level of ambition can be quantified into four levels, where 1 is the highest level and 4 is the lowest passing level.

The ambitious requirement for Active House includes all nine criteria and recommends the lowest level for each of them. As long as a criterion is better or equal to the lowest level of ambition, it is an Active House feature within that specific criterion.

The Active House Radar to the right shows how all criteria and goals within each principle are dependent on each other.

When (re)designing a dwelling or housing complex, the basic idea is to select individual and ambitious requirements for each criterion.

The Active House Radar is a great tool for displaying the ambition reached for the building with the calculated values. When the building is inhabited and the criteria are calculated based on measurements, the Radar can also be a useful tool for monitoring, evaluating and improving the building. As a communication tool, it provides a clarity as to why the integration of criteria is important for creating Active Houses.

To calculate the separate values displayed in the radar, different tools can be used. On the website of Active House (**www.activehouse.info**), a number of tools are available.

ACTIVE HOUSE RADAR

This figure shows how all criteria within each principle are balanced against each other. It also shows that the Active House criteria depend on active choice and prioritisation within each principle.

HOW TO USE THE SPECIFICATIONS

Active House focusses on nine criteria, that are featured in the Active House Radar. All criteria have both qualitative and quantitative aspects. The qualitative aspects are the 'softer' aspects, although they can have a profound influence on the design and design process of a building. These aspects are often process-oriented; some provide guidance on how to achieve the performance level described in the quantitative part, some provide guidance on how to achieve a more holistic approach (biodiversity, culture and local setting).

As the qualitative aspects are more meaningful during the initial stages of creating a building, they are listed in the description of every aspect.

The quantitative aspects of the nine Active House criteria can be expressed in numbers, and form the basis for the Active House radar.

EXAMPLE OF THE USE OF QUALITATIVE CRITERIA, BASED ON CHAPTER 2.1 ENERGY DEMAND.

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Demand on individual products and construction elements	Have the chosen products and construction solutions been evaluated from a cost-effective, life cost perspective and maintenance view?	All main solutions (roof, wall, foundation and windows) have been calculated from a cost-effective perspective within the individual solutions' lifetime. An evaluation of maintenance of technical solutions will be carried out.	YES
Architectural design solutions	Have architectural design solutions been used to reach a holistic approach of the building and to reach a low energy demand?	During the design phase, alternative design solutions have been modelled in BIM and the predicted performance of energy, indoor comfort and environment has been evaluated. The results were used to adjust and optimise the architectural design solution.	YES
Demand on individual appliances	Have the best energy performing solutions for appliances been chosen?	All white goods are minimum class A+ and all installed/in-built lamps are LED and evaluated for light quality.	YES

Montfoort, the Netherlands.
Photo: *Torben Eskerod.*

VELUXlab, Milan Italy.
Photo: *Andrea Segliani for VELUX.*

Key principles

KEY PRINCIPLES OF ACTIVE HOUSE

THE ACTIVE HOUSE KEY PRINCIPLES ARE AS FOLLOWS

COMFORT

- a building that provides an indoor climate that promotes health, comfort and sense of well-being
- a building that ensures good indoor air quality, adequate thermal climate and appropriate lighting levels and acoustical comfort
- a building that provides an indoor climate that is easy for occupants to control and at the same time encourages responsible environmental behaviour.

ENERGY

- a building that is energy efficient and easy to operate
- a building that substantially exceeds the statutory minimum in terms of energy efficiency
- a building that exploits a variety of energy sources integrated in the overall design.

ENVIRONMENT

- a building that exerts the minimum impact on environmental and cultural resources
- a building that avoids ecological damage
- a building that is constructed of materials with focus on re-use and re-purpose.

ACTIVE HOUSE MINIMUM REQUIREMENTS

An Active House is not a pre-set combination of technologies, materials or shapes. It can come in many different forms, typologies or functions. This is one of the attractions of the Active House vision for many designers: rather than following a fixed set of steps, they are invited to come up with their own solutions, combinations or innovations if they desire.

Because there are so many differences between buildings, it is unrealistic to compare them all against the same criteria at the same levels. Some buildings have strong emphasis on energy efficiency, others focus more on indoor climate, or having a low environmental footprint. This may result in differences in scores for the nine criteria expressed in the Active House Radar diagram.

All buildings can be Active Houses, if on the whole they provide a good performance. Emphasis on criteria may vary, but as long as the average score of all nine criteria equals 2,5 or less for new construction (renovation or existing buildings should score at least an average of 3,5), the building may call itself an Active House.

$$OverallActiveHouseScore = \frac{Sum\ of\ total\ scores\ of\ all\ 9\ Active\ House\ Parameters}{9} = \leq 2{,}5$$

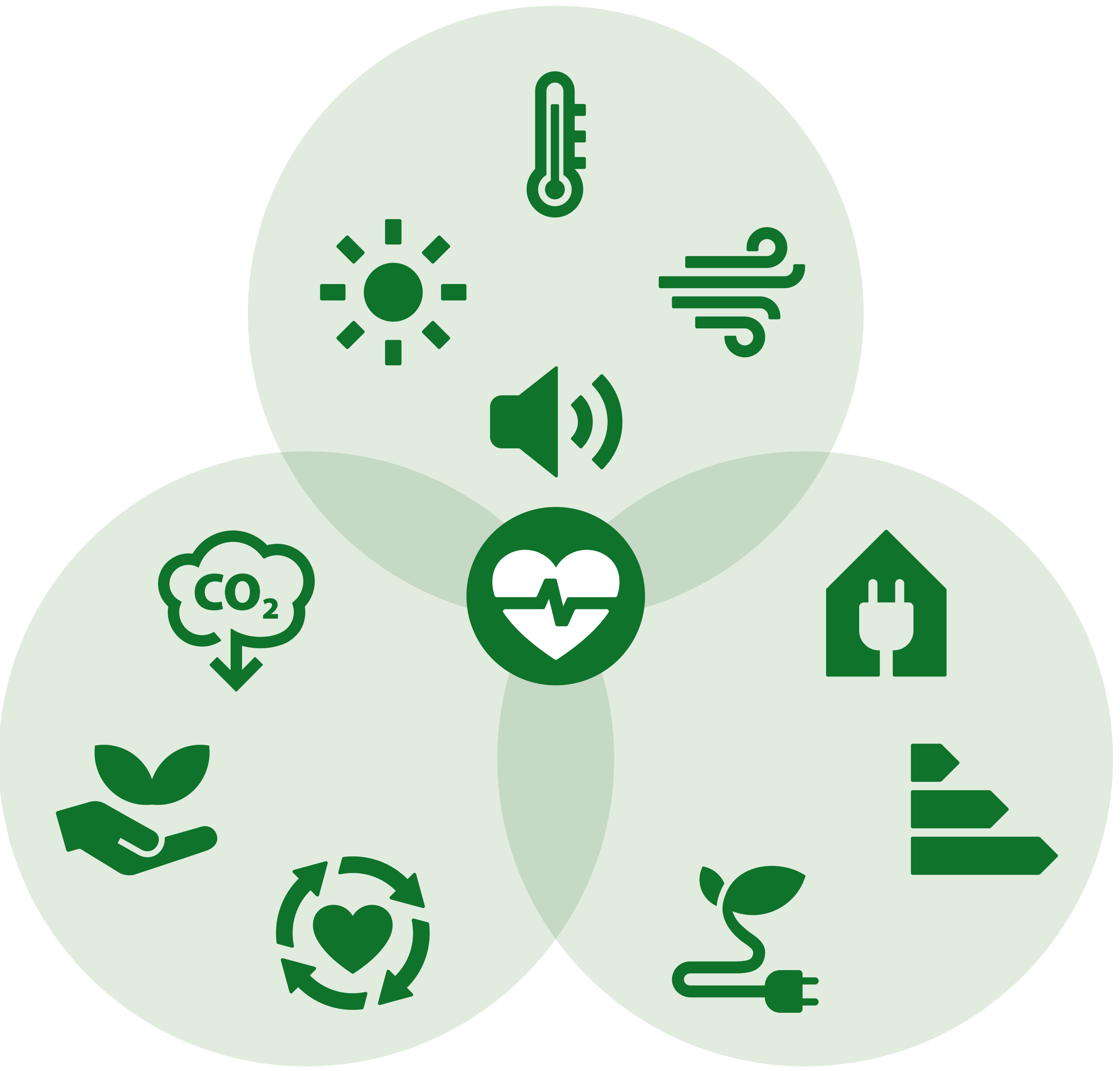
LangFang Office, Beijing China.
Photo: *Velux China.*

BUILDING MANAGEMENT

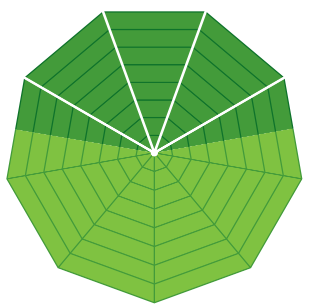
When designing an Active House, it must be ensured that the building in operation works as intended and that the users are capable of behaving as they intend.
In order to ensure efficient and responsible operation of the building and to assist building users in a responsible behaviour, it is important that the building and systems work as intended, that building users are aware of actual performance and that assistance is provided to promote efficient and responsible behaviour.

QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Management of indoor climate	• Training of building users in efficient behaviour. Yearly performance check of building and systems (service contract). • User guidelines on operation of building and technical systems Continuous (hourly) monitoring and display of performance and indoor air quality. • Commissioning of building, building services, shading and ventilation systems during the first year of operation.		
Management of energy	• Training of building users in energy-efficient behaviour. • Yearly performance check of building and systems (service contract). • User guidelines on energy-efficient operation of building and technical systems. • Continuous (hourly) monitoring and display of energy use and production. • Commissioning of building, building services and renewable energy systems during the first year of operation.		
Management of environment	• Training of building users in resource-efficient and responsible environmental behaviour. • Yearly performance check of building and systems (service contract). • User guidelines on optimal maintenance and water-efficient operation of building and technical systems. • Continuous monitoring and display of water use. • Commissioning of building, building services and water systems during the first year of operation.		



Sunlighthouse, Austria.
Photo: *Adam Mørk.*



1. Comfort

AN ACTIVE HOUSE OFFERS EXCELLENT INDOOR ENVIRONMENT

An Active House is a building that lets in abundant daylight and fresh air, thereby improving the quality of the indoor climate. This also means that the thermal environment is of high quality and that noise does not cause nuisance.

Most people spend 90% of our time indoors; therefore the quality of the indoor environment has a considerable impact on our health and comfort. A good indoor environment is a key quality of an Active House. It must be an integrated part of the house design to ensure good daylight conditions, thermal environment and indoor air quality. To support this process, the criteria in the specifications must be considered.
In order to evaluate each building's indoor climate, the four levels of ambition are used, as mentioned under Active House Radar earlier. Architects and engineers can use these levels to work towards creating their own specific levels for a building.

The criteria of comfort, daylight, thermal comfort and indoor air quality, should be weighted according to predicted or actual use. For daylight only the daylit hours of the use time should be considered assuming 12 hours of daylight (equinox, 21 March/ September). For thermal comfort and indoor air quality all hours should be used.
A typical week should be used including working days and weekend, by aggregating the usage hours per day for each day of the week and dividing by seven for the average daily values. The default hours of typical room types in table 1 can be used for residential buildings if no detailed calculations for the specific project is made.
For non-residential projects, other values should be used. For office buildings, distinguish between at least workplaces and individual meeting rooms. In case no detailed values are known, assume default values of 9 hours for a workplace and 4 hours for a meeting room. For evaluation of measured data, the actual use should be used. This way of calculating includes parallel use of rooms by different people.

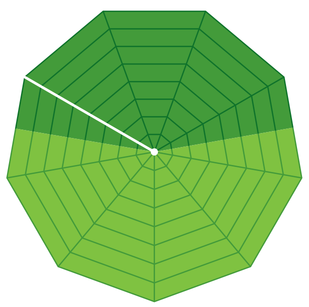
TABLE 1: EXAMPLE CALCULATION OF AVERAGE DAYLIGHT FACTOR USING DEFAULT NUMBERS FOR DIFFERENT ROOMS IN A HOUSE

ROOM	DF SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Kitchen	3	x	2.5	x	3	=	22.5
Living room	2	x	3	x	3	=	18
Bedroom parents	1	x	0.5	x	2	=	1
Bedroom child	2	x	1.5	x	1	=	3
SUBTOTAL			19				44.5
TOTAL AVERAGE SCORE							2.3

In this example, the living room is used 9 times more intensively than the master bedroom during daylight hours. This is expressed in the weighted score (score x intensity of use), which is 18 in this example, while the weighted score of the master bedroom is 1. The resulting Daylight score is (44.5 / 19) = 2.3

Green Solution House, Denmark.
Photo: *Adam Mørk.*

Haus am Venusgarten, Austria.
Photo: *Jörg Seiler.*



Daylight

1.1. AN ACTIVE HOUSE OFFERS OPTIMAL DAYLIGHTING

Adequate lighting and especially well-designed daylight penetration provide an array of health benefits to people in buildings. High levels of daylight and an optimised view out positively influence people's mood and well-being.

In an Active House it is thus important that the building allows for optimal daylight and attractive views to the outside. Electric lighting during daytime should rarely be necessary, which should make it possible to reduce the overall energy consumption for lighting.

1.1.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
View	Are windows located to offer the best possible views to the exterior environment (sky and surroundings)?		
Visual transmittance	Are windows that provide a view to the outdoors selected to have the highest possible visible transmittance?		
Glare management	Is dynamic shading present to avoid risk of glare?		
Daylight in secondary rooms	Have circulation zones and bathrooms access to daylight?		
Blinding of bedrooms	Do bedrooms have the possibility to block out all light coming from windows to create a full dark environment to sleep in?		
Room reflectance	What surface reflectances have been used in the daylight calculations? It is recommended to use the following values (typical ranges in brackets) Ceiling: 0.7 (0.7 to 0.9) Walls: 0.5 (0.5 to 0.8) Floor: 0.2 (0.2 to 0.4)		
Single or multiple openings	Does the room have access to daylight from more than one orientation and/or height?		
Simulation method	Has dynamic model simulation been used to determine the DA, rather than determining the DF?		

1.1.2. QUANTITATIVE CRITERIA EVALUATION METHOD

OPTION 1 - DAYLIGHT FACTOR

Building geometry, surrounding landscape, neighbouring buildings and surface properties (colour, diffuseness, specularity, transmittance, reflectance) are basic boundary conditions to assess daylight factor (DF), as the main quantitative classification of a project.

The calculation method of option 1 is based on the daylight factor method (method 1) in EN 17037.

- The amount of daylight in a room is evaluated using daylight factors on a horizontal work plane divided into a grid with a height above floor level of 0.85 m.
- Daylight factors must be calculated with a daylight simulation program validated against CIE 16:1970. The used sky type should be TYPE 1 or TYPE 16 from the ISO 15469:2004 and it should be stated what type is used in the calculations.
- The evaluation includes the living and activity zones (such as living room, workspace, dining room, kitchen, bedroom or children's room).
- Half of the daylit hours should have a fraction of space for the target level above the specified value for each category. Meaning that the daylight factor for each grid point should be higher than the daylight factor target level for a specific fraction of the grid, e.g. 60%.

Optimahouse, Ukraine.
Photo: *Alexander Kucheravy.*

DAYLIGHT

ASPECT	VALUE	CRITERIA	SCORE
Daylight factor per room		The amount of daylight in a room is evaluated through the fraction of the room, $F_{plane,\%}$, that have a daylight factor higher than the target daylight factor (D_T): 1. $F_{plane,\%}$ > 70 % of the occupied space 2. $F_{plane,\%}$ > 60 % of the occupied space 3. $F_{plane,\%}$ > 50 % of the occupied space 4. $F_{plane,\%}$ > 40 % of the occupied space Daylight factors are calculated using a validated daylight simulation program according to EN 17037.	

D_T depends on location and by that the median external diffuse illuminance $E_{v,d,med}$. Values of $E_{v,d,med}$ for different nations / capitals are shown in Annex 1 together with the corresponding values of D_T.

$$D_r = \frac{Illuminance\ level}{E_{v,\,d,\,med}} = \frac{illuminance\ level}{E_{v,\,d,\,med}} = \frac{300\ lx}{E_{v,\,d,\,med}}\ x100\ \{\%\}$$

$E_{v,d,med}$ can be calculated using hourly values of the diffuse horizontal illuminance from the sky using yearly weather data. $E_{v,d,med}$ is median of the 4380 highest hourly values, equivalent to the 75^{th} percentile of the yearly data.

Total average score = total weighted score/total hours use

The total average score is based on multiplying the score for each room with the amount of hours spent and the number of people in that room during daylight hours, then dividing by the total number of people-hours (see also table 1 on page 10).
In case no actual or predicted use numbers are available, use the default use hours in the table below.

This way, the rooms that are being used while there is daylight, such as the living room, will contribute with higher weight than, for example, the master bedroom, which is used by adults mostly during the night.

ROOM	DF SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Kitchen		x	2.5	x		=	
Living room		x	3.0	x		=	
Bedroom parents		x	0.5	x		=	
Bedroom child		x	1.5	x		=	
(additional rooms)		x		x		=	
SUBTOTAL							
TOTAL AVERAGE SCORE							

Green Solution House, Denmark.
Photo: Stamers Kontor, Laura Stamer.

DAYLIGHT

OPTION 2 - DAYLIGHT AUTONOMY

In case of deeper interest in daylight qualities, climate-based daylight performance metrics can be used. Climate based daylight simulations enable to consider further design factors as seasons, time of day, façade (window) orientation, location (latitude) of the building, climate circumstances, direct solar ingress, shading and glare prevention, variable sky conditions, building type and occupant requirements.

The calculation preconditions for the climate based daylight-modelling relies on the method described in EN17037 - Daylight in Buildings, Daylight provision calculation method 2. For a space with vertical and/or inclined opening with a given target illuminance of 300 lx, at least 25% of the yearly hours, the results shall be above the target value. The minimum illumination limit is 300 lx in residential buildings. In case office or other public buildings are evaluated, the limit is 500 lx.

ASPECT	VALUE	CRITERIA	SCORE
Target daylight level per room		The amount of daylight in a room is evaluated through daylight levels with a target illuminance of 300 lux in dwellings or 500 lx in office or other public buildings. $DA_{300/50}$ 1. > 70% of the occupied space 2. > 60% of the occupied space 3. > 50% of the occupied space 4. > 40% of the occupied space	

Total average DA = total weighted score/total hours use

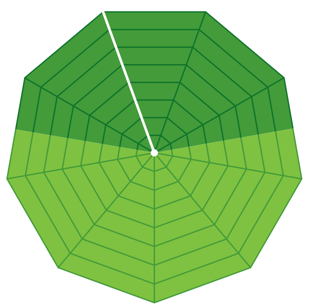
The total average DA is based on multiplying the DA300/50 dwelling (DA500/50 offices) for each room with the amount of hours spent and the number of people in that room during daylight hours, then dividing by the total number of people-hours (see also table 1 on page 10). In case no actual or predicted use numbers are available, use the default use hours in the table below.

This way, the rooms that are being used while there is daylight, such as the living room, will contribute with higher weight than, for example, the master bedroom, which is used by adults mostly during the night.

ROOM	DF SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Kitchen		x	2.5	x		=	
Living room		x	3.0	x		=	
Bedroom parents		x	0.5	x		=	
Bedroom child		x	1.5	x		=	
(additional rooms)		x		x		=	
SUBTOTAL							
TOTAL AVERAGE SCORE							

First Active House, Russia.
Photo: *Torben Eskerod.*

Sunlighthouse, Austria.
Photo: *Adam Mørk.*



Thermal environment

1.2. AN ACTIVE HOUSE OFFERS AN OPTIMAL THERMAL ENVIRONMENT

A pleasant thermal environment is essential for a comfortable home. Adequate thermal comfort, both in summer and winter, enhances the mood, increases performance and, in some cases (e.g. in houses for the elderly), prevents and alleviates diseases.

Active Houses should minimise overheating in summer and optimise indoor temperatures in winter without unnecessary energy use. Where possible, use simple, energy-efficient and easily maintained solutions.

There are no requirements for maximum temperature in the winter (heating period) and minimum temperature in the summer (cooling period), as these are related to the behaviour of the users of the building. This is a deviation from EN16798-1. However, in well-insulated buildings, there is a potential risk of overheating in winter, in case floor heating is unable to provide cooling and solar irradiation on a bright day can cause an uncomfortable build-up of heat. Care should be taken in the design stage to prevent the risk of overheating.

1.2.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Individual control, winter	Is it possible to adjust the temperature at room level according to momentary needs, e.g. with adjustable thermostats?		
Individual control, summer	Is it possible to manually influence the thermal conditions in each room, e.g. by opening windows or adjusting solar shading? In the case of mechanical cooling systems, is it possible to adjust the temperature at room level, e.g. with adjustable thermostats?		
Night cooling	Is it possible to remove excess heat that has built up during the day, through high volume night-time ventilation with cool outdoor air?		
Overheating, winter	Is it possible to remove unwanted excess heat in winter, e.g. on sunny days, without creating uncomfortable draughts?		
System interface	Have the climate system interfaces (e.g. wall thermostats) been selected to be as intuitive and simple as possible?		
Draught	Have ventilation openings (including windows, ventilation grilles and mechanical ventilation devices) been located and detailed so that discomfort caused by draught is minimised? Typical airspeeds within the living zone should remain below 0.2 m/s in winter and 0.5 m/s in summer **Note:** *Adjustability (e.g. of operable windows and ventilation grilles) is an important issue to take into account in this context.*		

1.1.2. QUANTITATIVE CRITERIA EVALUATION METHOD

- To objectify the risk of overheating, a dynamic thermal simulation tool is used to determine hourly values of indoor operative temperature at room level (e.g. in living rooms, kitchens and bedrooms, or office spaces). In buildings without mechanical cooling systems (like central air conditioning), adaptive temperature limits are used in the summer months. This means that the maximum allowable temperature inside is linked to the weather outside: limits go up during warmer periods.

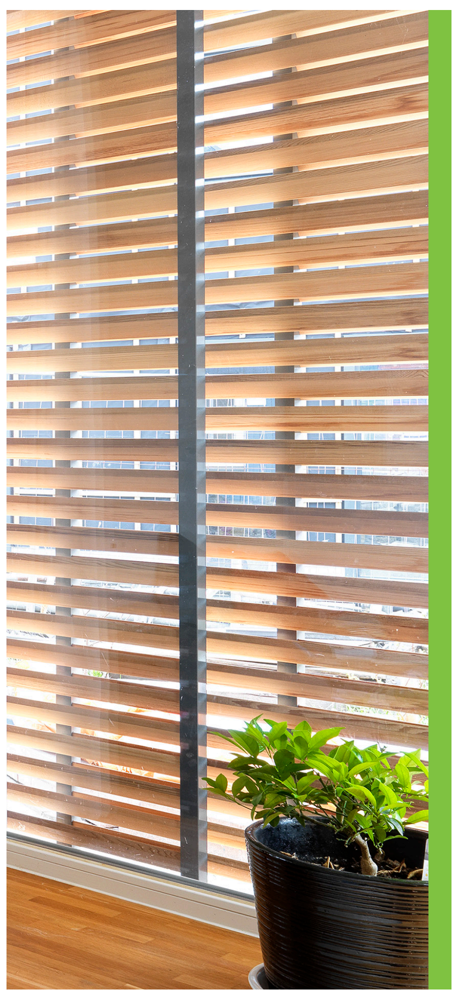
- Requirements should be met for a minimum of 95% of occupied time.

- The score is based on the weighted average of all evaluated rooms. Occupancy hours should be included in the weighting.

THERMAL ENVIRONMENT

ASPECT	VALUE	CRITERIA	SCORE
Maximum operative temperature per room		The maximum indoor temperature limits apply in periods with an outside T_{rm} of 12°C or more. For rooms/spaces in buildings without mechanical air conditioning and with adequate opportunities for natural (cross or stack) ventilation, the maximum indoor operative temperatures are: 1. $T_{i,o} < 0.33 \times T_{rm} + 20.8°C$ 2. $T_{i,o} < 0.33 \times T_{rm} + 21.8°C$ 3. $T_{i,o} < 0.33 \times T_{rm} + 22.8°C$ 4. $T_{i,o} < 0.33 \times T_{rm} + 23.8°C$ T_{rm} is the Running Mean outdoor temperature as defined in 'paragraph 3.12 External temperature, running mean' of EN 16798-1. For rooms/spaces in buildings with air conditioning, the maximum operative temperatures are: 1. $T_{i,o} < 25.5°C$ 2. $T_{i,o} < 26°C$ 3. $T_{i,o} < 27°C$ 4. $T_{i,o} < 28°C$ For bedrooms (especially at night time), a 2°C lower value than indicated above should be used as people are more sensitive to high temperatures when sleeping or trying to fall asleep. Also, in kitchens higher temperatures than indicated can be allowed periodically, e.g. during cooking activities. The system should be designed to achieve recommended values. The users can, however, choose their own settings. Reference: EN 16798-1.	
Minimum operative temperature per room		The minimum indoor temperature limits apply in periods with an outside T_{rm} of 12°C or less. For living rooms, kitchens, study rooms, bedrooms etc. in dwellings, the minimum operative temperatures are: 1. $T_{i,o} > 21°C$ 2. $T_{i,o} > 20°C$ 3. $T_{i,o} > 19°C$ 4. $T_{i,o} > 18°C$ The system should be designed to achieve recommended values. The users can, however, choose their own settings.	
		AVERAGE SCORE	

Active House Erasmushove, The Netherlands.
Photo: *Dick Holthuis.*



Total average score = total weighted score/total hours use

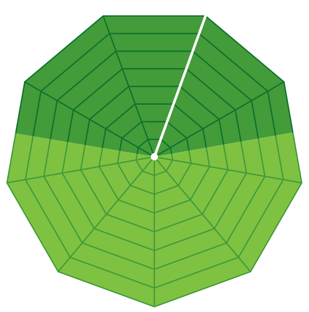
The total average score is based on multiplying the thermal comfort score for each room with the amount of hours spent in that room during a week (weekdays and weekend), then dividing by the total number of hours (see for example also table 1 on page 10). In case no actual or predicted use numbers are available, use the default use hours in the table below.

This way, the rooms that are being used more intensively will contribute with higher weight.

ROOM	AVERAGE SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Maximum operative temperature							
Kitchen		x	3.5	x		=	
Living room		x	5	x		=	
Bedroom parents		x	8.5	x		=	
Bedroom child		x	11	x		=	
(additional rooms)		x		x		=	
Minimum operative temperature							
Kitchen		x	3.5	x		=	
Living room		x	5	x		=	
Bedroom parents		x	8.5	x		=	
Bedroom child		x	11	x		=	
(additional rooms)		x		x		=	
SUBTOTAL							
TOTAL AVERAGE THERMAL COMFORT SCORE							

RhOME, Italy.
Photo: *Lorenzo Procaccini.*

Green Solution House, Denmark.
Photo: *Stamers Kontor, Laura Stamer.*



Indoor air quality

1.3. INDOOR AIR QUALITY SHOULD BE OPTIMAL IN AN ACTIVE HOUSE

Good indoor air quality can prevent humans from developing respiratory ailments, such as mucous membrane irritation, asthma and allergies. It can also contribute to prevent some cardiovascular diseases. High indoor air quality helps to avoid odour problems, which can positively affect the overall well-being of the building's occupants.

Active Houses should provide good air quality for the occupants while minimising energy use e.g. for ventilation. This means that natural ventilation through open windows should be possible, and mechanical ventilation systems should be demand driven, preferably in combination with zoning (living and sleeping) of the dwelling. Humidity has a limited effect on thermal sensation and perceived air quality; however, long-term high humidity levels indoors will cause microbial growth.

To avoid problems related to dampness and mould, it shall be guaranteed that there is sufficient extraction in rooms with periodic damp-production peaks (especially kitchens, bathrooms and toilets). The minimum exhaust air flow in these 'wet rooms'

should be achievable as specified in national building codes or guidelines and the exhaust systems shall secure that the daily limit value for relative humidity in wet rooms such as bathrooms is below 80%.

1.3.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Individual control	Is it possible to manually influence the air exchange rate in the rooms (especially living room, kitchen and bedrooms), e.g. by opening windows, temporarily closing air grills, or if mechanical ventilation is installed, is it possible to adjust the airflow rate at three or more levels?		
Dampness	Is it guaranteed that there is sufficient extraction in rooms with periodic moisture-production peaks (esp. kitchens, bathrooms and toilets)? **Note:** *The minimum exhaust air flow for toilets, bathrooms and kitchens should be 35, 50 and 70 m3/h, according to category II of EN16798-1.*		
Low-emitting building materials	Have indoor climate-labelled materials been used? **Note:** *many labels exist, for example, Danish Indoor Climate label, M1 label, AgBB, GUT label, Blue Angel, GreenGuard Gold label.*		
Kitchen	Is a kitchen hood present with a capacity of at least 300 m^3/h with the exhaust directly to the outside?		
Outdoor air filtration	In case the building is situated at a location with poor outdoor air quality, is filtration present in the fresh air supply.		

1.3.2. QUANTITATIVE CRITERIA EVALUATION METHOD

- Fresh air supply can be evaluated by examining indoor CO_2 concentrations at room level during occupancy. CO_2 is a good indicator of the amount of bio-effluents, pollutants from humans, in the air.
- CO_2 emission per person should be set at 20 l/h and 13.6 l/h per person for living rooms and bedrooms respectively (reference: EN 16798-1).
- The requirements should be met for a minimum of 95% of occupied time.
- The classification of the air quality is determined as the use-time-weighted hourly average of all room scores.
- The minimum requirements as specified in national codes should always be followed.

INDOOR AIR QUALITY

ASPECT	VALUE	CRITERIA	SCORE
Standard fresh air supply per room		The fresh air supply shall be established according to the below limit values for indoor CO_2 concentration in living rooms, bedrooms, study rooms and other rooms with people as the dominant source and that are occupied for prolonged periods: 1. < 400 ppm above outdoor CO_2 concentration 2. < 550 ppm above outdoor CO_2 concentration 3. < 800 ppm above outdoor CO_2 concentration 4. < 1100 ppm above outdoor CO_2 concentration	

Total average score = total weighted score/total hours use

The total average score is based on multiplying the indoor air quality score for each room with the amount of hours spent and the number of people in that room during a week (weekdays and weekend), then dividing by the total number of people-hours (see for example also table 1 on page 10). In case no actual or predicted use numbers are available, use the default use hours in the table below.

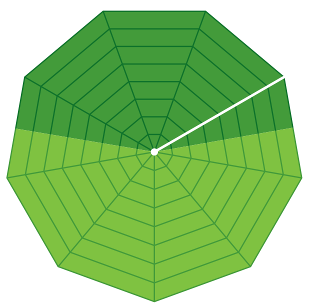
This way, the rooms that are being used more intensively will contribute with higher weight.

ROOM	AVERAGE SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Kitchen		x	3.5	x		=	
Living room		x	5	x		=	
Bedroom parents		x	8.5	x		=	
Bedroom child		x	11	x		=	
(additional rooms)		x		x		=	
SUBTOTAL							
TOTAL AVERAGE INDOOR AIR QUALITY SCORE							

Photo: *Adam Mørk.*

Green Lighthouse, Denmark.
Photo: *Adam Mørk.*

Green Lighthouse, Denmark.
Photo: *Adam Mørk.*



Acoustic quality

1.4. AN ACTIVE HOUSE OFFERS A QUIET LIVING ENVIRONMENT

A quiet living environment is an important aspect of a healthy home. Noise, or unwanted sound, can cause annoyance, hypertension, stress and impair sleep, among other things. For this reason, an Active House protects against unwanted sound, both from indoor sources and outdoor sources.

Because not all sound is perceived equally, distinction is made between sound that users have little or no control over, and noise coming from sources that are produced by the users of the building. Therefore, noise coming from, for example, the building installations or traffic noise from outside is addressed in these specifications, while children playing or music from another room is not.

1.4.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Inside system noise	Has extra attention been given to rooms that require extra quietness, such as bedrooms and study rooms?		
Acoustic privacy	Are inner walls and floor divisions designed to reduce noise transmission between rooms?		
External spaces	In case external spaces are present, such as a garden or balcony, have measures been taken to create a quiet environment?		

1.4.2. QUANTITATIVE CRITERIA EVALUATION METHOD

- All main occupied spaces should be assessed.
- If the building has one or more bedrooms, the lowest scoring bedroom determines the overall score for the inside system and outside noise criteria. In that case, it supersedes the weighting of different rooms.
- Rather than assessing the minimum sound-insulating value of outer wall constructions, the resulting maximum indoor sound level is assessed. This way, the construction can be optimised for different locations with different external sound levels, with buildings on quiet locations needing fewer measures than buildings on sound heavy locations, while still scoring the same.
- The levels are aimed at setting ambitions for calculations at the design stage. After completion, when questions arise whether the ambitions are achieved, measurements can be done. These can be done by a professional, but also with a noise meter app on a smartphone.
- The limit values are based on ISO 140-4

LangFang Office, Beijing China.
Photo: *Alexander Kucheravy.*

ACOUSTIC QUALITY

ASPECT	VALUE	CRITERIA	SCORE
Inside system noise		The limit values are: 1. < 25 dB or noise level at or below background noise level 2. < 30 dB 3. < 35 dB 4. < 40 dB After completion, noise from all mechanical services in continuous operation is measured in all main occupied spaces. In case an adjustable mechanical ventilation system is present, the noise levels should at least be met at the ventilation rate that meets the indoor air quality ambition level. The noise levels from the table above can temporarily be exceeded to the next level, when the ventilation flow rate is increased due to removal of pollutants or humidity such as during cooking or showering.	
Outside noise		The maximum indoor noise levels from outdoor sources are: 1. < 25 dB 2. < 30 dB 3. < 35 dB 4. < 40 dB Noise from outside sources such as traffic or industry should be prevented from entering the building. Local outdoor noise level data can normally be found in so called noise contour maps that are made available online by local government. Assuming that calculations/measurements are done with operable windows and outside doors closed.	
Acoustic privacy		Within connected dwellings, such as apartment buildings, neighbours can be a source of noise, so it is important to have walls and floors that limit the noise transfer. Difference is made between airborne sound ($D_{nT,A}$) and contact sound ($L_{nT,A}$). The limit values are: 1. $D_{nT,A}$ ≥ 62 dB and $L_{nT,A}$ ≤ 43 dB 2. $D_{nT,A}$ ≥ 57 dB and $L_{nT,A}$ ≤ 48 dB 3. $D_{nT,A}$ ≥ 52 dB and $L_{nT,A}$ ≤ 53 dB 4. $D_{nT,A}$ ≥ 47 dB and $L_{nT,A}$ ≤ 58 dB	
		AVERAGE SCORE:	

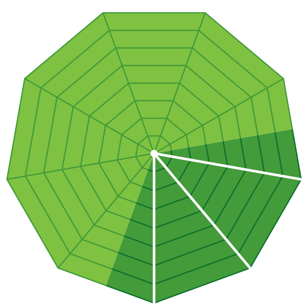
Total average score = total weighted score/total hours use

The total average score is based on multiplying the acoustic quality score for each room with the amount of hours spent and the number of people in that room during a week (weekdays and weekend), then dividing by the total number of people-hours (see for example also table 1 on page 10). In case no actual or predicted use numbers are available, use the default use hours in the table below. This way, the rooms that are being used more intensively will contribute with higher weight.

ROOM	AVERAGE SCORE		HOURS		NO. OF PEOPLE		WEIGHTED SCORE
Kitchen		x	3,5	x		=	
Living room		x	5	x		=	
Bedroom parents		x	8,5	x		=	
Bedroom child		x	11	x		=	
(additional rooms)		x		x		=	
SUBTOTAL							
TOTAL AVERAGE ACOUSTIC QUALITY SCORE							

Thorold Active House, Canada.
Photo: *Thorben Eskerod.*

Active House Solbjerg, Denmark
Photo: *Torben Eskerod Photography.*



2. Energy

ACTIVE HOUSES REALISE THE GREAT POTENTIAL TO USE ENERGY MORE EFFICIENTLY IN BUILDINGS

An Active House is energy efficient and supplied by renewable energy sources integrated in the building or from the nearby collective energy systems, including possible zonal or national electricity grids.

Globally, heat and electricity in buildings account for 40% of all energy consumption. Considering the total energy consumption throughout the whole life cycle of a building, the energy performance and energy supply are important issues in the concern about climate changes, reliability of supply and reduced global energy waste.

The design, orientation and products for an Active House are optimised to use as little energy as possible and to utilise renewable energy sources as much as possible.

The design of an Active House should be based on the Trias Energetica approach to sustainable design. The main focus of the concept is the fact that the most sustainable energy source is the energy being saved. From bottom to top of the Trias Energetica pyramid, the messages are as follows:

1. **Minimise the energy demand of the building. To do so, use energy-efficient solutions and architectural measures, such as orientation, awnings and shading, materialisation and shape of the building.**

2. **Source the remaining energy requirement as much as possible from renewable and CO_2-free energy sources, either on the building, the plot or from the nearby energy systems.**

3. **Any remaining energy demand may be met by using fossil fuels through highly-efficient energy-conversion processes.**

Energy plays a vital role in buildings. To the user, energy consumption during the use-stage is most visible, as it is directly linked to energy demand of the building, on-site renewable energy production and to energy bills. However, the materials used to build the house contain a large amount of embodied energy that should not be overlooked. To stimulate the conscious use of different energy sources, distinction is made between final energy (which is metered at the building) and primary energy.

QUALITATIVE CRITERIA – EXTENDED ENERGY DEMAND, PRIMARY ENERGY PERFORMANCE AND ENERGY SUPPLY

The building energy demand, primary energy performance and energy supply are calculated according to the diverse national building energy assessment methods to enable comparison of projects in a country and to create a common energy evaluation platform based on the different national building energy requirements in the building permit process.

In case of interest in deeper insight in building energy performance, or need for comprehensive comparative analysis between design concepts under different climate conditions, dynamic energy performance calculations can be used. Dynamic energy simulations enable to consider time dependent design factors such as hourly resolution of yearly climate data (seasons, time of day), building types, space and façade (window) orientation, precise location (latitude), usage (light, equipment, occupants), losses and gains, shading and glare prevention, as well as operation. In addition to winter comfort and heating performance, the modelling can include detailed summer thermal comfort, cooling energy efficiency and high-resolution mechanical and natural ventilation assessments as well.

The distinguished handling of the diverse weather profiles helps to characterize and compare projects in the same or in different geographic site-locations in a sophisticated way.

ENERGY

Since the main purpose of the national building energy calculations is to secure the 'worst case' scenario, the oversizing of the HVAC systems is state-of-the-art in common design practice. As a result, investment, operation and LCA-LCCA costs increase. Application of dynamic energy simulations ensure lower system sizing with all of its benefits.

The workflow is mainly identical to the one of a thermal and air hygiene comfort simulation, by 3d-modelling of the spaces, modelling of the HVAC systems and the controlling. The definition of time basis occupancy, equipment and lighting schedule profiles are recommended to keep results as realistic as possible. 'Mimicking' the real usage and operation of the building, occupant and equipment user 'behaviour' are to be included in the simulations with detailed lighting operation. Comparison of in-situ, real building monitoring measurements and the simulation model, the operation management can be significantly improved and optimized. In the simulation framework three main calculation goals can be achieved:

→ Building performance (effect of space organization, shape, wall-window-ratio, orientation, neighbourhood-landscape, structures and materials)

→ Services systems (heating-cooling, AHU, lighting) and natural ventilation systems performance

→ Building management system (BMS automation, monitoring-controlling) performance

Most dynamic thermal simulation programs possess a unified simulation environment of comfort and energy performance, ensuring a comprehensive evaluation platform between them. In this way more realistic energy demand and consumption results are gained.

Results are to be calculated using a dynamic simulation tool validated by the US BESTEST (ANSI/ASHRAE Standard 140). Examples of applicable daylight and thermal (comfort and energy) simulation programs can be found at:

https://www.buildingenergysoftwaretools.com/

It is recommended that energy simulations deliver high-resolution information about the buildings energy usages and – if in the simulation software included – about comfort performance, such as to enable higher level of design optimisation.

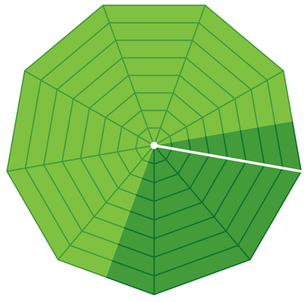
QUALITATIVE CRITERIA – ENERGY VALIDATION ON SITE

In addition to focus on energy performance in the design phase, proper execution of the design is crucial to achieve the desired energy performance. Consequently, it is deemed most appropriate to consider the following criteria:

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Onsite control of solutions and products	Has onsite control focused on proving that the energy solutions and products meet the designed level?		
Air permeability of the building is maximum 1 ACH at 50 Pa	Has the air permeability of the building been tested?		
Thermal bridges	Have the thermal bridges been evaluated during the construction phase?		
Qualification of the controller	Has the control been established by a certified expert?		
Real world validation after one year	After completion of the building, does the real world energy performance meet the designed performance?		

First Active House, Russia.
Photo: *Torben Eskerod.*

Casa sul parco, Italy.
Photo: *Matteo Piazza.*



Energy demand

2.1. ACTIVE HOUSES KEEP THE ENERGY DEMAND LOW

Building-coupled energy demand is calculated by including all energy needed for the building (including space heating, ventilation, air conditioning including cooling and associated technical installations). New buildings will typically have a low energy demand, while renovated buildings allow for a higher demand.

User-coupled energy demand includes energy consumption for domestic water heating and lighting. Appliances such as a fridge, television or computer, are included only as heat gains in a heat balance calculation, accounting for reduced heating or increased cooling demands.

In the design phase, it is important to focus on minimising the use of energy by minimising heat loss through the building envelope. This includes heat loss by conduction and air infiltration through external construction elements.

It is crucial to adopt a holistic approach to the use of energy. This means, for example, that an Active House should be optimised with maximum use of solutions that are not

energy intensive. Such solutions could be solar gain, daylight, natural ventilation, night ventilation cooling, solar shading etc. Shading of exposed facades and windows shall be established when needed, either as a permanent summer solution or as dynamic intelligent solution.

The definition of the useful heated floor area shall follow the national definition.

2.1.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Demand on individual products and construction elements	Have the chosen products and construction solutions been evaluated from a cost-efficient, life-cost perspective and maintenance view?		
Architectural design solutions	Have architectural design solutions been used to reach a holistic approach of the building, as well as to reach a low energy demand?		
Passive cooling solutions	Have solutions been included in the design to minimise the need for active cooling through air conditioning?		
Simulation method	Has dynamic model simulation been used to gain deeper insight into the energy performance?		

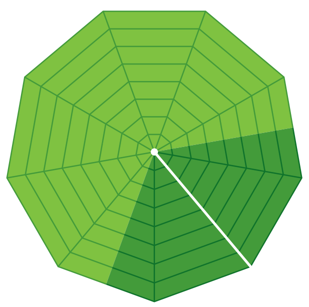
2.1.2. QUANTITATIVE CRITERIA EVALUATION METHOD

The annual energy demand for the building includes energy demand for space heating, ventilation, air conditioning including cooling, domestic hot water and lighting.

The annual energy demand shall follow the national calculation methodology.
The calculation of useful heated floor area shall follow the national method.
The requirements to individual products and construction elements (i.e. minimum thermal resistances, maximum thermal bridge effects and airtightness) shall at least follow requirements set in national building regulations.

ASPECT	VALUE	CRITERIA	SCORE
Annual energy demand - building		1. < 40 kWh/m^2 2. < 60 kWh/m^2 3. < 80 kWh/m^2 4. < 100 kWh/m^2	

Optimahouse, Ukraine.
Photo: *Alexander Kucheravy.*



Energy supply

2.2 RENEWABLE ENERGIES SUPPLY AN ACTIVE HOUSE

The goal is that the energy supply to an Active House shall be based on renewable and CO_2-neutral energy sources in accordance with the energy performance classification chosen. Ideally, the building is able to cover the total energy demand with self-generated sustainably sourced energy.

From a building perspective, not all energy is valued the same. In order of relevance, first the building-coupled energy demand should be covered: heating, cooling, ventilation, and building installations. Second, the user-coupled energy demand should be covered: user appliances, warm water, and lighting. If a surplus of energy is still available, it can be used for non-building related energy demand, such as (electric) mobility. Any energy that remains after that can be fed into the main grid.

There are no specific requirements to where and how the renewable energy is produced. It must, however, be documented that the energy comes from renewable energy in the energy system.

2.2.1. QUALITATIVE CRITERIA

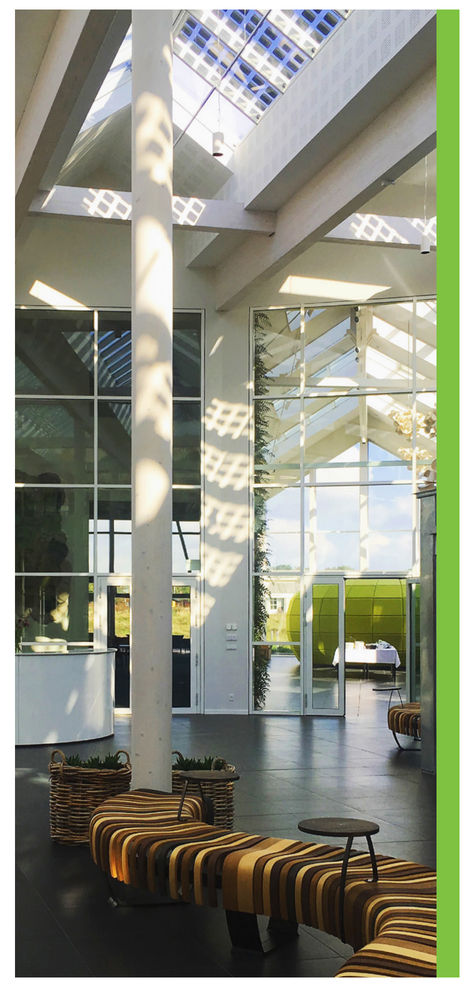
ASPECT	CRITERIA	ARGUMENTS	YES/NO
Design	Has integration of renewable energy been worked with as a part of the building design and typology of the building and the plot?		
Origin of energy supply	Has the energy supply been evaluated from a cost perspective, and how was the decision about the origin of the energy supply made?		

2.2.2. QUANTITATIVE CRITERIA EVALUATION METHOD

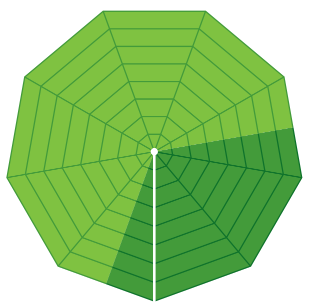
- The annual energy supply from renewable energy and CO_2-free energy sources shall be calculated and divided into the different sources (solar thermal, heat pumps, biomass, PV, wind etc).
- The definition of renewable energy sources follows the EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009).
- Requirements to performance of the individual renewable source shall follow the requirements in national building legislation. As an alternative to national requirements, the requirement in the EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009) can be used.
- Renewable energy sources can either be in or on the building or on the site. If the renewable energy comes from an energy system or electricity grid it should have a direct connection to the building.
- The definition of nearby system and boundaries for renewable energy on the plot follows the national or European definitions.

ASPECT	VALUE	CRITERIA	SCORE
Origin of energy supply		Energy produced on the plot or in a nearby system is able to cover the total energy used in the building for: 1. > 100 % 2. > 75 % 3. > 50 % 4. > 10 %	

Green Solution House, Denmark.
Photo: *Alexander Kucheravy.*



Green Lighthouse, Denmark.
Photo: *Adam Mørk.*



Primary energy performance

2.3. ACTIVE HOUSES INCLUDE ANNUAL NON-RENEWABLE PRIMARY ENERGY PERFORMANCE

The annual non-renewable primary energy performance shall be based on national figures on primary energy. The calculation shall include energy demand for the building as well as the energy supply from renewable energy.

2.3.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
Energy use and CO_2 emissions	Has the non-renewable energy source been optimised such as to have the lowest primary energy factor and lowest emissions?		

2.3.2. QUANTITATIVE CRITERIA EVALUATION METHOD

- The primary energy performance =
  (total energy used – renewable energy supply) x national primary energy factors.

- The total energy used includes the building and user coupled energy consumption.

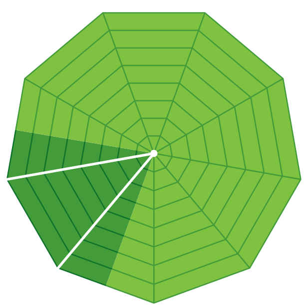
- The energy demand and the energy produced by renewable sources must be monitored on a yearly basis. Metering devices are to be used for all types of energy production/consumption at the building level.
- The annual energy performance evaluation shall specify the supply from:
  - individual renewable energy sources integrated into the building
  - energy supply from local energy system and the share of renewable energy as well as the CO_2 emissions from the local energy system.

- Calculation of primary energy and CO_2-emissions shall be based on the national calculation methodology, using nationally-adopted efficiency/conversion and emission factors, as well as climate data.

ASPECT	VALUE	CRITERIA	SCORE
Annual non-renewable primary energy performance		1. 0 kWh/m^2 2. < 50 kWh/m^2 3. < 100 kWh/m^2 4. < 130 kWh/m^2	

RenovActive, Belgium.
Photo: *Adam Mørk.*

Sunlighthouse, Austria.
Photo: *Adam Mørk.*



3. Environment

ACTIVE HOUSES AIM TO HAVE A POSITIVE IMPACT ON THE ENVIRONMENT

An Active House will have an impact on the environment – it should be as minimal as possible. This means that any harm to environment, soil, air and water should be minimised.

The challenges we face regarding the environment are a reality on a local, regional and global level. Global environmental resources are under pressure from over-consumption and pollution. The pressure is felt at a regional and a local level too.

When developing an Active House, it is important to ensure that such challenges are considered at both global, regional and local levels. This is important in order to ensure a new generation of buildings and products that aim to have a positive impact on the environment.

Montfoort, the Netherlands.
Photo: *Torben Eskerod.*

Consideration should be given in the design phase for how Active Houses use building materials and resources.

It is also possible to consider the local building culture and behaviour in and around the local buildings as well as traditions, climate and ecology. This is relevant when working on improving the building's exterior and interior relations to the cultural and ecological site-specific context.

The key criteria to consider within resource and emissions are:
- Sustainable construction, containing recycled content and environmental loads from materials
- Freshwater consumption

ACTIVE HOUSES NEED RIGOROUS EVALUATION

When evaluating the performance of an Active House, it is important to consider the consumption of energy resources and the emissions to air, soil and water through a Life Cycle Assessment in accordance with the EN 15643 series on sustainable construction or with ISO 14040. Life Cycle Assessment must be developed according to EN15978 or ISO21931-1.

The building's life cycle is considered at the following stages:
- Production of building materials
- Use of materials in the operation of the building
- End of life of building materials
- Transport and site processes may be omitted

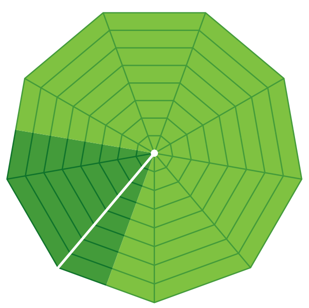
At least, all major building components should be considered, that is:
- Outside walls, roofs, slabs, foundations, windows and doors
- Inner walls, floors and ceilings
- Major technical components (heat generators , ventilation, storage, solar thermal collectors and PV-systems etc.)

The estimated service life of the building should be in accordance with local standards. Active House suggests 50 years as benchmark. The estimated service life of all building components should be in accordance with local standards and experiences.
Active House LCA-tool (from www.activehouse.info) should be used for the development of the life cycle assessment.

Environmental Product Declaration (EPD) and average data from public sources or software tools can be used as long as they are applicable to the country or region. EPDs must be developed according to EN15804 or ISO 21930:2017

The following impact categories are to be evaluated:
- Impact categories (emissions):
- Global warming potential (GWP)
- Ozone depletion potential (ODP)
- Photochemical ozone creation potential (POCP)
- Acidification potential (AP)
- Eutrophication potential (EP)

Future Active House, Norway.
Photo: *Torben Eskerod.*



Sustainable construction

3.1. ACTIVE HOUSES TAKE SUSTAINABLE CONSTRUCTION AND SOURCING INTO CONSIDERATION

When designing an Active House, it is important to evaluate recycled or reused content and sourcing. It is preferable to include building components or elements that have already been used (re-use), or materials reclaimed from old buildings or processes (recycle), to reduce the environmental load of the building materials.

A distinction is made between recycled content (that has already been used) and virgin material that could be recycled or reused at the end-of-life stage of the building. The recycled content includes pre-consumer, internal and post-consumer recycling. Recyclable content is aimed at materials or elements that can be reclaimed post-consumer. Both are evaluated by weight and shall take into consideration 80% of the weight of the building.

LangFang Office, Beijing China.
Photo: *Velux China.*

Responsible sourcing includes the requirement to use certified sourcing either directly, like PEFC and FSC for sourcing of wood, and EPD (environmental product declaration) for other materials.

The process of constructing a new building causes various emissions to air, soil and water, which have different impacts on the environment. When constructing an Active House and conducting a Life Cycle Assessment, it is important to know and consider the different impact categories of these emissions, which may have serious environmental effects. They are explained in the following:

- **GLOBAL WARMING POTENTIAL (GWP)**
  The accumulation of so-called greenhouse gases in the troposphere causes increased reflection of infrared radiation from the earth's surface. Consequently, the temperature on the earth's surface rises. This phenomenon is referred to as the 'greenhouse effect', affecting human health, ecosystems and society in general. The global warming potential groups together gases in relation to the impact of carbon dioxide (CO_2).

- **OZONE DEPLETION POTENTIAL (ODP)**
  Ozone (O3) occurs as a trace gas in the stratosphere (10-50 km altitude) and absorbs solar UV radiation. However, human emissions induce the thinning of the stratospheric ozone layer since certain gases, such as halocarbons, work as catalysts degrading ozone to oxygen. Thus the transmission of UV-B radiation is increased, with potentially harmful impacts on human health, terrestrial and aquatic ecosystems, causing for example DNA-damage, cancer (especially skin cancer) and eye irritation, crop failures and the decrease of planktons. The ozone depletion potential groups together the impact of various ozone depleting gases. The reference variable used is R11 (trichlorofluoromethane CCl3F).

- **PHOTOCHEMICAL OZONE CREATION POTENTIAL (POCP)**
  A higher concentration of ozone in the troposphere (0-15 km altitude), the so-called summer smog, is toxic to humans and may also cause damage to vegetation and materials. When exposed to solar radiation, nitrogen oxide and hydrocarbons form round level (tropospheric) ozone in a complex chemical. This process is called photochemical oxidant creation. Nitrogen oxides and hydrocarbons are produced during partial combustion. The latter is also created by using petrol or solvents. The ozone formation potential is related to the impact of ethylene (C_2H_4).

- **ACIDIFICATION POTENTIAL (AP)**
  Acidification of soil and water results from the conversion of airborne pollutants into acids. The major acidifying pollutants are sulphur dioxide (SO_2), nitrogen oxides (NO_x) and their acids (H_2SO_4 and HNO_3). These gases are generated during combustion processes in power stations and industrial buildings, in homes, by cars and small consumers. Acidification has a wide range of impacts on vegetation, soil, groundwater, surface waters, biological organisms, ecosystems and building materials, e.g. forest decline and acid rain. The acidification potential groups together all the substances contributing to acidification in relation to the impact of sulphur dioxide (SO_2).

- EUTROPHICATION (EP)

Eutrophication means excessive fertilisation of soil or water and describes the concentration of nutrients and nutrient enrichment in an ecosystem, which may cause an undesirable shift in species composition and elevated biomass production. The major nutrients are nitrogen (N) and phosphorus (P). These substances are contained in fertilisers, nitrogen oxides from combustion engines, domestic wastewater, industrial waste and wastewater. Plants in excessively fertilised soils exhibit weakening of their tissue and lower resistance to environmental influences. In aquatic ecosystems, increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition[1]. This may result in fish death and the biological death of water. Furthermore, a high concentration of nitrate can render groundwater and surface waters unusable as drinking water since nitrate reacts and becomes nitrite, which is toxic for human beings. The eutrophication potential groups together the substances in comparison to the impact of phosphate (PO_4).

3.1.1. QUALITATIVE CRITERIA

ASPECT	CRITERIA	ARGUMENTS	YES/NO
LCA of the building	Were the results of an LCA used to optimise the design?		
Responsible sourced wood	Has effort been made to use as much certified wood as possible (FSC, PEFC)?		
Responsible sourced building materials	Has effort been made to use as many building materials as possible with a label indicating responsible origin or production?		
Job site management	Were the following items considered to minimise the impact of the job site? • Optimise the management of construction waste • Limit nuisance and pollution • Minimise resource consumption • Respect workers		
Disassembly	Has the building been designed so that 70% by weight of the building will be able to be reused, recycled or backfilled at its end of life? This will meet and anticipate the European Directive on construction waste. *(European Directive from 2008 (2008/98/EC)* *• Waste hierarchy* *• Construction and demolition waste: 70% by weight by 2020 (re-use, recycling and backfilling of 70%).*		
Biodiversity	Has respect for fauna, flora and the environment been considered, in order to provide nests for birds, create green vegetation, minimise chemical treatment, etc.?		

[1] Handbook on Life Cycle Assessment, Guinée, Kluwer academic publishers, p.82

3.1.2. QUANTITATIVE CRITERIA EVALUATION METHOD SUSTAINABLE CONSTRUCTION

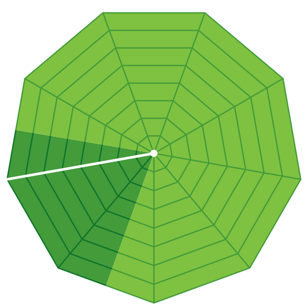
ASPECT	VALUE	CRITERIA	SCORE
Recycled content		By weight, the average of recycled or reused content for all building materials (weighted by the proportion of the material in the building) is: 1. > 20% 2. > 10% 3. > 5 % 4. > 0 % 80% of the weight of the building should be accounted for. *(In the recycled content, we take into account internal, pre-consumer and postconsumer recycling).*	
Recyclable or reusable virgin content		By weight, the average of recyclable or reusable virgin content for all building materials (weighted by the proportion of the material in the building) could be: 1. > 50% 2. > 30% 3. > 10% 4. > 5% 80% of the weight of the building should be accounted for. *(In the recyclable or reusable content, we take into postconsumer recycling or reuse).*	
Responsibly sourced wood		1. > 75 % of the wood used is certified (FSC, PEFC) 2. > 50 % of the wood used is certified (FSC, PEFC) 3. > 25% of the wood used is certified (FSC, PEFC) 4. > 0 % of the wood used is certified (FSC, PEFC)	
Declared origin		1. > 75 % of the new material has a certified EPD 2. > 50 % of the new material has a certified EPD 3. > 25 % of the new material has a certified EPD 4. > 0 % of the new material has a certified EPD	
		AVERAGE SCORE:	

3.1.3. QUANTITATIVE CRITERIA EVALUATION METHOD ENVIRONMENTAL LOADS

ASPECT	VALUE	CRITERIA	SCORE
Global warming potential (GWP) during building's life cycle.		1. < -30 kg CO_2-eq./m^2 x a 2. < 10 kg CO_2-eq./m^2 x a 3. < 40 kg CO_2-eq./m^2 x a 4. < 50 kg CO_2-eq./m^2 x a	
Ozone depletion potential (ODP) during building's life cycle		1. < 2.25E-07 kg R_{11}-eq/m^2 x a 2. < 5.3E-07 kg R_{11}-eq./m^2 x a 3. < 3.7E-06 kg R_{11}-eq./m^2 x a 4. < 6.7E-06 kg R_{11}-eq./m^2 x a	
Photochemical ozone creation potential (POCP) during building's life cycle.		1. < 0.0025 kg C_3H_4-eq./m^2 x a 2. < 0.0040 kg C_3H_4-eq./m^2 x a 3. < 0.0070 kg C_3H_4-eq./m^2 x a 4. < 0.0085 kg C_3H_4-eq./m^2 x a	
Acidification potential (AP) during building's life cycle.		1. < 0.010 kg SO_2-eq./m^2 x a 2. < 0.075 kg SO_2-eq./m^2 x a 3. < 0.100 kg SO_2-eq./m^2 x a 4. < 0.125 kg SO_2-eq./m^2 x a	
Eutrophication potential (EP) during building's life cycle.		1. < 0.0040 kg PO_4-eq./m^2 x a 2. < 0.0055 kg PO_4-eq./m^2 x a 3. < 0.0085 kg PO_4-eq./m^2 x a 4. < 0.0105 kg PO_4-eq./m^2 x a	
		AVERAGE SCORE:	

ASPECT	SCORE
Sustainable construction average score	
Environmental loads average score	
TOTAL AVERAGE SCORE:	

Green Solution House, Denmark.
Photo: *Alexander Kucheravy.*



Freshwater consumption

3.2. ACTIVE HOUSES MINIMISE FRESHWATER CONSUMPTION

The depletion and scarcity of global freshwater resources are escalating and thus it is becoming increasingly important to consider water consumption – and treatment – during the life-time of an Active House.

For example, when freshwater is saved, it results in wastewater savings as well and both issues are part of the specifications – wastewater as qualitative indications. Freshwater consumption can be reduced by installation of water-saving tabs, use of grey or rain water for toilets and gardening, and the use of easy-to-clean surfaces.

3.2.1. QUALITATIVE CRITERIA

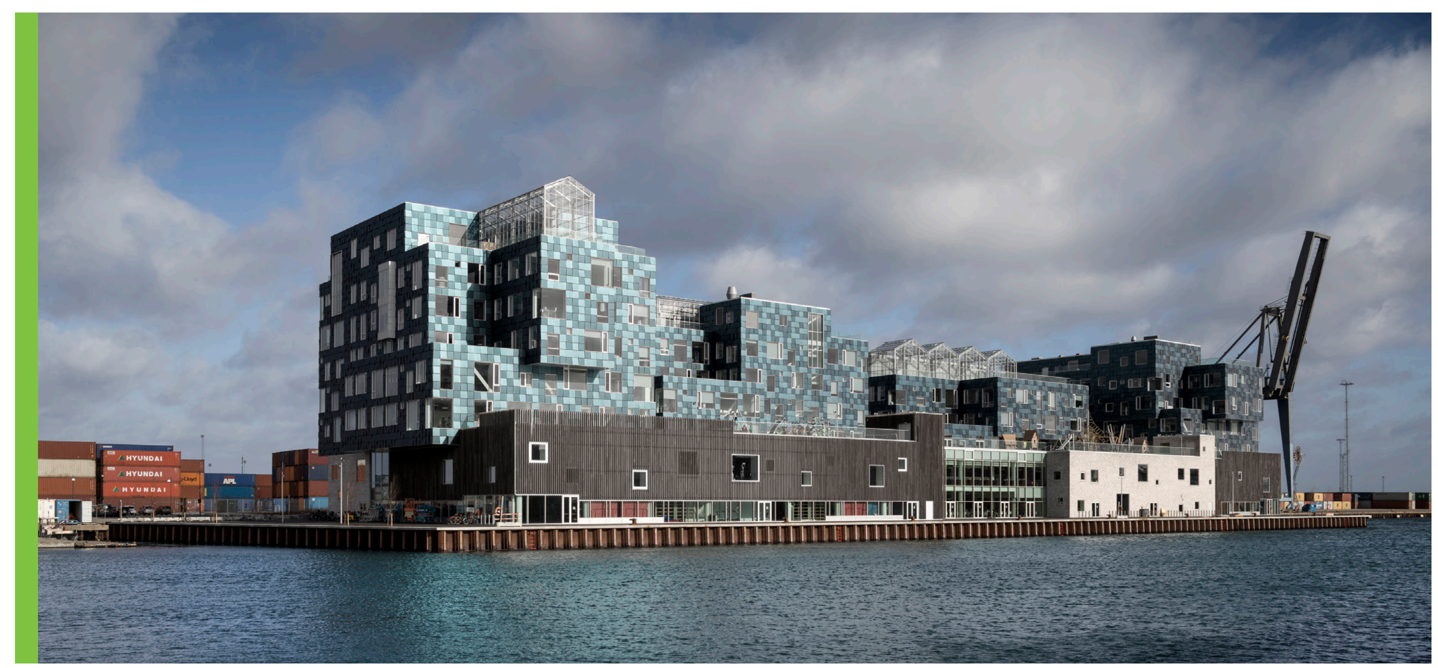
ASPECT	CRITERIA	ARGUMENTS	YES/NO
Appliances	Have water saving appliances been installed?		
Use of grey or rain water	Is grey or rain water used to reduce the water consumption in garden, toilets and for washing?		
Storm water runoff	Are measures in place to prevent rainwater from entering the sewerage system?		

3.2.2. QUANTITATIVE CRITERIA EVALUATION METHOD

How many water saving features are included in the building? To determine the fresh water score, determine the water usage of toilets, shower and taps. Water efficient taps are recommended throughout the building, with a possible exemption to be made for the kitchen tap.

ASPECT	VALUE	CRITERIA	SCORE
Toilet water use		Toilet water usage 1. < 4 litre per flush 2. < 6 litre per flush 3. < 9 litre per flush 4. < 12 litre per flush	
Shower water use		Flowrate of showerhead 1. < 6 litre per minute 2. < 8 litre per minute 3. < 10 litre per minute 4. < 12 litre per minute	
Tap water use		Tap flow rate 1. < 3 litre per minute 2. < 5 litre per minute 3. < 7 litre per minute 4. < 9 litre per minute	
		TOTAL AVERAGE SCORE:	

Copenhagen International School, Denmark.
Photo: *Adam Mørk.*



Annex 1

Simulating daylight factor: a grid with a spacing of approximately 0.1 m is adequate and a band of 0.5 m from the walls should be omitted from the work plane.

Nation	Capital	Geographical latitude	Median External Diffuse Illuminance - $E_{v,d,med}$	D to exceed 300 lx
Cyprus	Nicosia	34,88	18100	1,7 %
Malta	Valletta	35,54	16500	1,8 %
Greece	Athens	37,9	19400	1,5 %
Portugal	Lisbon	38,73	18220	1,6 %
Turkey	Ankara	40,12	19000	1,6 %
Spain	Madrid	40,45	16900	1,8 %
Italy	Rome	41,8	19200	1,6 %
Bulgaria	Sofia	42,73	18700	1,6 %
Romania	Bucharest	44,5	18200	1,6 %
Croatia	Zagreb	45,48	17000	1,8 %
Slovenia	Ljubljana	46,22	17000	1,8 %
Switzerland	Bern	46,25	16000	1,9 %
Hungary	Budapest	47,48	18100	1,7 %
Austria	Wien	48,12	16000	1,9 %
Slovakia	Bratislava	48,2	16300	1,8 %
France	Paris	48,73	15900	1,9 %
Luxembourg	Luxembourg	49,36	16000	1,9 %
Czech Republic	Prague	50,1	14900	2,0 %
Belgium	Brussels	50,9	15000	2,0 %
United Kingdom	London	51,51	14100	2,1 %
Poland	Warsaw	52,17	14700	2,0 %
The Netherlands	Amsterdam	52,3	14400	2,1 %
Germany	Berlin	52,47	13900	2,2 %
Ireland	Dublin	53,43	14900	2,0 %
Lithuania	Vilnius	54,88	15300	2,0 %
Denmark	Copenhagen	55,63	14200	2,1 %
Latvia	Riga	56,57	13600	2,2 %
Estonia	Tallinn	59,25	13600	2,2 %
Sweden	Stockholm	59,65	12100	2,5 %
Norway	Oslo	59,9	12400	2,4 %
Finland	Helsinki	60,32	13500	2,2 %
Iceland	Reykjavik	64,13	11500	2,6 %

Results are to be calculated using a dynamic simulation tool with integrated/ combined Radiance ray-tracer solver engine or equal.

PARAMETER	DESCRIPTION	MINIMAL	FAST	ACCURATE	VERY ACCURATE	MAX
-ab	Ambient bounces	0	0	2	5	8
-aa	Ambient accuracy	0.5	0.2	0.15	0.08	0
-ar	Ambient resolution	8	32	128	512	0
-ad	Ambient divisions	0	32	512	2048	4096
-as	Ambient super-samples	0	32	256	512	1024

Active House Centennial Park - first labelled Active House.
Photo: *Torben Eskerod Photography.*

Acknowledgements

THE ACTIVE HOUSE SPECIFICATION 3rd EDITION IS AN UPDATE OF THE 2nd EDITION.

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Bas Hasselaar, DGMR (NL)

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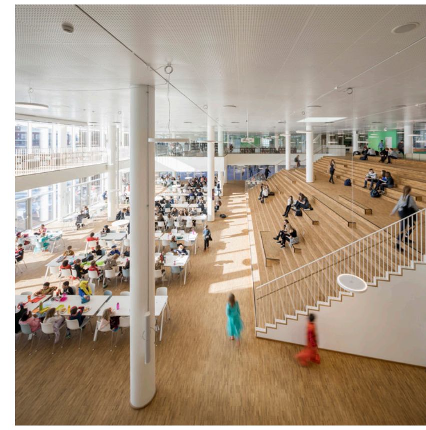

Photo: *Adam Moerk.*

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ACTIVE HOUSE

network and knowledge sharing

Active House Alliance members support the vision of Active House and are committed to taking an active role in promoting this vision.

The Active House Alliance includes companies and organisations from the construction sector as well as manufacturers, architects, engineers and research and knowledge centres from the construction sector.

On becoming a member of the Active House Alliance, you are invited to participate in internal workshops and knowledge-sharing activities as well as in the development of the alliance and the materials and specifications being developed.

Members of the alliance are also invited to participate in training regarding those specifications and they are allowed to use the tools developed by the alliance.

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.

Contact the Active House Secretariat at: secretariat@activehouse.info

Read more at www.activehouse.info

Solbjerg Active House.
Photo: *Torben Eskerod Photography.*

The International Active House Alliance

The International Active House Alliance is a global network between: Academia & Knowledge institutions, Designers & Planners, Developers & Builders, Building Industry Producers, who think alike on how sustainable buildings work, are created and delivered. The Alliance is a non-profit organization of partners working with a holistic view of sustainable buildings, based on the three guiding principles: comfort, energy and the environment.

The **Alliance** was established in 2011, following a roundtable in 2009 which set a first vision for the Alliance and several processes which put the spotlight on the acceleration of climate change and the need to use resources more carefully, however not excluding the user parameters of a good indoor climate and long-lasting qualities of building design. In 2016, the alliance defined the Active House label, a non-profit quality mark for the broader building market.

Today there are 7 national Alliances, multiplying the membership into a global community of partners who aim to scale sustainable cities with smart buildings, creating long lasting value.

The Active House principles are recognized amongst the top 10 certification schemes, and is truly global working across the value chain of buildings, from knowledge over designers and planning, with engineers, industries and developers working from the key principles. **Healthy Buildings for People & Planet.**

The Active House Alliance is a wide and well consolidated partner platform between public, private, industry and consumers – an example of the Sustainable Development Goal # 17.

NATIONAL ALLIANCES

INTERNATIONAL ALLIANCE

PARTNER ORGANISATIONS

www.activehouse.info secretariat@activehouse.info