ACTIVE HOUSE - Specification

Buildings that give more than they take

1st. Edition

Photo by Adam Mørk

Introduction

Today, the world faces several environmental challenges. Our natural resources are scares, global warming needs yet to be tackled and our well-known sources of energy are being depleted.

Meanwhile, there is a need to meet essential human needs for a healthy, comfortable indoor climate. Active House seeks to respond to these factors. These specifications represent the next generation within sustainable buildings with a focus on well-being for the users.

This report outlines the specification for designing an Active House, described as a building that combines energy efficiency with specific attention to the indoor climate and focussing on user's health and well-being. The scope of this specification is residential buildings. The specification outlines the vision behind Active House, sets down key principles which have influenced the evolution of the Active House concept, and outlines the technical specification for an Active House.

The Active House specification is intended to be a guideline for construction and design industries at an international level. It seeks innovative approaches at technical levels whilst introducing goals of architectural quality and environmental design responsiveness and still securing energy efficiency.

Photo by Adam Mørk

Through science, knowledge sharing and real life experiments with local adaptations, practitioners and experts have worked dedicated to bringing to life this vision of creating buildings which contribute positively to the energy balance, and creates a healthier and more comfortable life, and has positive impact on the environment.

These specifications have been developed using an open-source model. The development has involved online debates and contributions as well as offline meetings and workshops with broad participation across the building industry globally.

These specifications launched now are indeed the first edition. The next steps will focus on communicating the specification, and continuing the dialogue based on the experience from the practical application of the specification.

The knowledge gained from the dialogue will be used to develop and improve the next edition of the specification, which is expected to be within two years time.

Bruxelles, 14 April 2011

Colourbox

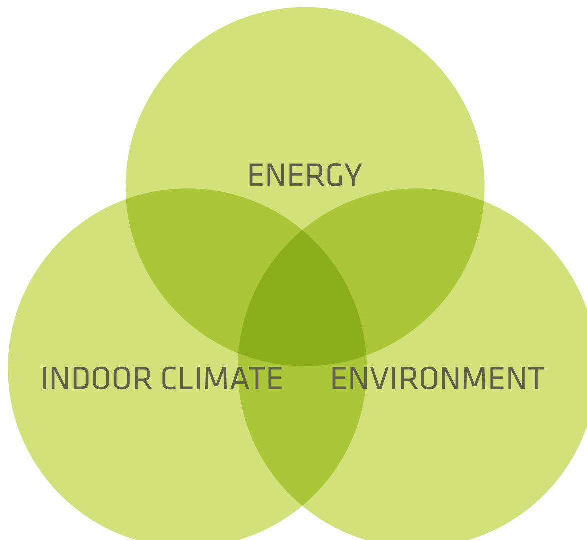
Photo by Adam Mørk

1.0 Vision

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

The Active House vision defines highly ambitious long term goals for the future building stock. 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 e.g. building projects, product development, research initiatives and performance targets that can move us further towards the vision.

Active House proposes a target framework for how to design and renovate buildings that contribute positively to human health and wellbeing 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 external environment.



ENERGY - Contributes positively to the energy balance of the building
An Active House is energy efficient and all energy needed is supplied by renewable energy sources integrated in the building or from the nearby collective energy system and electricity grid.

INDOOR CLIMATE - Creates a healthier and more comfortable life
An Active House creates healthier and more comfortable indoor conditions for the occupants and the building ensures generous supply of daylight and fresh air. Materials used have a positive impact on comfort and indoor climate.

ENVIRONMENT - Has a positive impact on the environment
An Active House interacts positively with the environment by means of an optimised relationship with the local context, focused use of resources, and on its overall environmental impact throughout its life cycle.

1.1 Key principles

1.1 KEY PRINCIPLES OF ACTIVE HOUSE

An important aspect of the Active House concept is that of 'integration'. Although Energy, Indoor Climate and Environment are essential components of the vision, it is the way their integration promotes architectural quality, human health, comfort and well-being which represents the value of the building. Integration is:

- A building which integrates the demands of comfort, climate, energy, environment and ecology into an attractive whole
- A building where such integration adds to architectural quality and human well-being
- A building whose interactive systems and spaces add to human enjoyment and support environmentally responsive family life

With focus on the tree key principles:

ENERGY

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

INDOOR CLIMATE

- An indoor climate that promotes health, comfort and sense of well-being
- A building which ensures good indoor air quality, adequate thermal climate and appropriate visual and acoustical comfort
- An indoor climate which is easy for occupants to control and at the same time encourages responsible environmental behavior

ENVIRONMENT

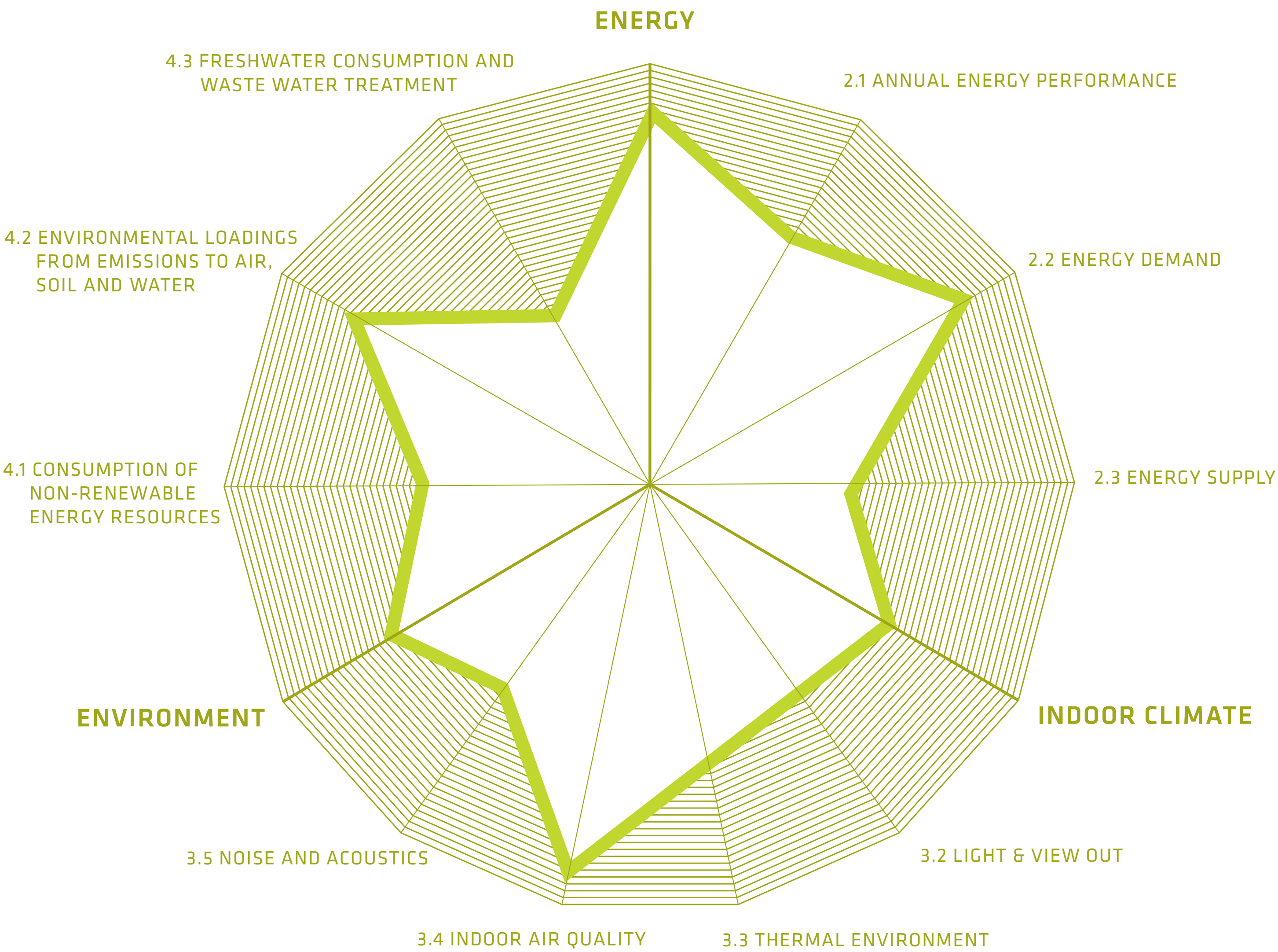
- A building which exerts the minimum impact on environmental and cultural resources
- A building which avoids ecological damage and seeks to add to local biodiversity
- A building which is constructed of materials which have high recycled content and which provides the ability for its own recycling or re-use

Photo by Morten Fauerby

1.2 Active House Radar

1.2 ACTIVE HOUSE RADAR

An Active House is the result of efforts to actively integrate the three main principles of Energy, Indoor Climate and Environment in the design of a building and in the finished building. This figure shows how all parameters within each principle are balanced against each other. It also shows that the Active House parameters depend on active choices within each parameter.


ENERGY
2.1 ANNUAL ENERGY PERFORMANCE
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2.3 ENERGY SUPPLY
INDOOR CLIMATE
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3.3 THERMAL ENVIRONMENT
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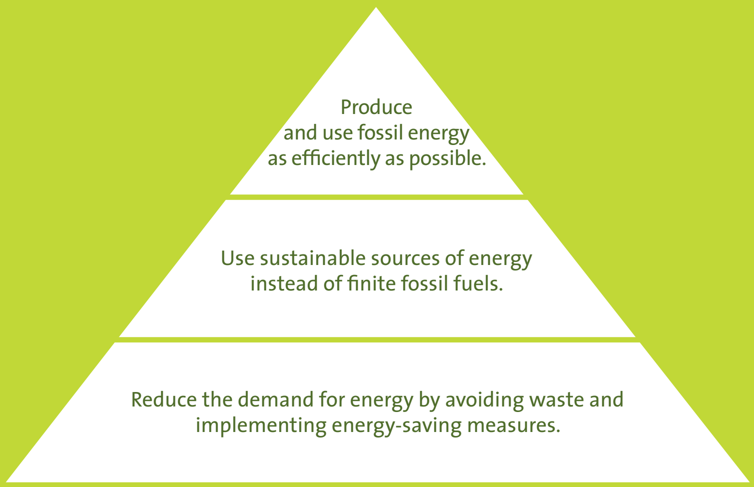
2.0 Energy

Globally, we consume approximately 40% of all the energy for heating, cooling and electricity in buildings. Considering the total energy consumption throughout the whole life cycle of a building, the energy performance and energy supply is an important issue in the concern about climate changes, security of supply and reduced global energy consumption.

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

This is why the design of an Active House shall be based on the Trias Energetica, a three step approach to sustainable design:
1) First, minimize the inherent energy demand of the building through architectural measures, such as orientation, materialisation and shape of the building,
2) Second, source the remaining energy requirement as much as possible from renewable and CO_2-free energy sources, either on the building, plot or the energy system.
3) Any remaining energy demand may be fulfilled by using fossil fuels through highly efficient energy conversion processes.

The Trias Energetica concept: the most sustainable energy is saved energy.



2.1 Annual energy performance

2.1 ANNUAL ENERGY PERFORMANCE
In an Active House the annual energy performance shall be based on primary energy calculations and it includes energy demand for the building and appliances, as well as the energy supply from renewable energy. The requirements to energy demand, renewable energy and validations follow in chapter 2.2-2.4.

An Active House can be classified on the basis of the annual energy performance, where new buildings preferably should be classified as category 1 - 3, while category 4 only should be used for modernization of buildings.

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Energy and CO_2-calculation	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. The definition of the heated floor area shall follow the national definition.
	Annual energy performance	The annual energy performance shall be based on primary energy calculations and it includes calculation of the energy demand of the building, the energy demand of appliances and a calculation of the renewable energy being used. An Active House is classified according to the annual primary energy use, where: 1: ≤ 0 kWh/m2 for the building and appliances 2: ≤ 0 kWh/m2 for the building 3: ≤ 15 kWh/m2 for the building 4: ≤ 30 kWh/m2 for the building (modernization)

2.2 Energy demand

2.2 ENERGY DEMAND

When calculating the energy demand of an Active House it is important to include all energy needed for the building and the appliances. The energy demand classification includes the energy demand for the building. New buildings will typically have a low energy demand, while renovated buildings allow for a higher demand.

When designing for the use of energy in an Active House it is important to focus on minimizing the heat loss from the building including transmission through constructions, thermal bridges etc. The energy performance of construction products, construction elements, thermal bridges, air tightness, etc. shall at least follow the national requirements on these areas. The same is valid for the calculation methodology.

In the design phase it is crucial to include a holistic approach to the use of energy. This means for example that an Active House should be optimized with maximum use of solutions, which are not energy intensive. Such solutions could be using solar gain, daylight; natural ventilation etc. This same approach is relevant in order to reduce the need for cooling. Shading of exposed facades and windows shall be established, either as permanent summer shading or preferred dynamic shading as intelligent insulation of glazed facades.

The management system of an Active House has to be simple to use for the users of the building. The system has to contribute to the increase of the quality of the indoor climate as well as minimize the energy use of the building.

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Annual energy demand for the building	The annual energy demand includes energy demand for space heating, water heating, ventilation, air conditioning including cooling, technical installations and electricity for lighting. 1: ≤ 30 kWh/m2 2: ≤ 50 kWh/m2 3: ≤ 80 kWh/m2 4: ≤ 120 kWh/m2 (modernization only)
	Annual energy demand for appliances	The annual energy demand for appliances includes white goods, television, computers and similar equipment.
	Demand to individual products and construction elements	The requirements to individual products and construction elements (i.e. minimum thermal resistances, maximum thermal bridge effects, and air tightness) shall at least follow requirements set in national building regulations.
	Building management system	An Active House should be prepared for an easy and user- friendly control of the indoor climate and the energy use in the building.
Qualitative	Demand to individual products, construction elements and appliances	Have the chosen products and construction solutions been evaluated from a cost perspective and maintenance view and how was the decision about the individual products and construction solutions taken? Have the best energy performing solutions for appliances been chosen?
	Architectural design solutions	How is architectural design solutions used to reach a holistic approach of the building, as well as to reach a low energy demand?

2.3 Energy supply

2.3 ENERGY SUPPLY

The goal is that the energy supply to an Active House shall be based on renewable energy sources in accordance with the energy performance classification chosen.

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. If the building is supplied with less than 100% renewable energy from the energy system, the rest of the energy supply must be produced on the building or the plot and delivered back to the energy system.

The requirement and definition to renewable energy follows the national interpretations and the EU Directive on the promotion of the use of energy from renewable sources.

The qualitative requirements for an Active House focus on the design and it is required that the designer evaluate the integration of renewable energy sources on the building or the plot. Such evaluation will be on individual basis but it must be proven that the evaluation has taken place.

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Annual energy supply	The annual energy supply from renewable energy and CO_2-free energy sources shall be calculated and divided into the different sources (PV, Wind, Heat pumps, Solar Thermal, Biomass, etc).
	Origin of energy supply	The renewable energy sources can either be used on the building, the site, in a nearby energy system or electricity grid. The energy supply can be a mix of the above and follow the classifications below: 1: 100% of the energy is produced on the plot 2: more than 50% of the energy is produced on the plot 3: more than 25% of the energy is produced on the plot 4: less than 25% of the energy is produced on the plot
	Sources of renewable energy	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).
	Performance of renewable energy system	Requirement to performance of the individual renewable source shall follow the national requirement in 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.
Qualitative	Design	How have you worked with integration of renewable energy as a part of the building design and typology on 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 taken?

2.4 Energy validation

2.4 ENERGY VALIDATION
During constructions an on site surveys should be established to secure that the building is build according to the specification and calculation.

It is crucial to establish a method to calculate the annual energy use and the annual energy supply in an Active House.

In an Active House it is important to establish a monitoring and commission period. This is in order to ensure that the energy used is used as expected. Information about the annual energy performance shall be made available for the house owner.

	PARAMETER	EVALUATION METHOD AND CRITERIA
Quantitative	Specification of figures	The calculation of the annual demand shall specify the energy demand for the individual areas, as specified in section 1.2: • space heating, water heating, ventilation, cooling and air-conditioning, electricity for technical equipment, electricity for lighting and electricity for appliances 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
	On site control	In order to prove that the build energy solutions meet the designed level, an on site control of the used solutions and products must be established by a certified expert. The air permeability of the building and the thermal bridges must be evaluated during the construction phase.
	Monitoring	The energy used and the energy produced must be monitored on a yearly basis. Metering devices are to be used for all types of energy production/consumption at the building level.
Qualitative	Quality control	What kinds of quality control of the energy performance have taken place, where and when was it done?
	Commissioning	How will the commissioning of the building take place and will the commissioning include user behaviour, number of users, heating and ventilation system, control of dynamic solutions and production of renewable energy? If the use of energy is different from the calculated values, what kinds of initiatives are planned to meet the calculated values?
	User guidelines	What kinds of initiatives have been taken to secure that the house owner and users of the building have the relevant information about the expected performance of the building and guidance to use and optimize the building?
	Energy control	What kinds of initiatives have been taken to secure the users' possibilities to control and optimize the use of energy?
	Maintenance	What kinds of initiatives have been taken to secure the users a possibility to maintain the technical equipment as well as other parts of the building that affect the energy performance?

Sources and tools: *National calculation methodology, national primary factors and climate data, EU Directive on energy performance of buildings (2010/31/EC of 19 May 2010), EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC of 23 April 2009), national test and evaluation methods, like Blower door test and thermograph photos.*

3.0 Indoor Climate

3.0 INDOOR CLIMATE

We spend 90% of our time indoors; therefore the quality of the indoor climate has a considerable impact on our health and comfort. A good indoor climate is a key quality of an Active House, and ensuring good indoor air quality, an adequate thermal climate and appropriate visual and acoustical comfort must be an integrated part of the house design. To support this process, the parameters below must be considered.

The requirements for the indoor climate in an Active House are both qualitative and quantitative. The evaluation of quantitative parameters will place the building (or a specific room) in one of four categories from 1 to 4, with category 1 having the highest level of performance and 4 the lowest (see table 1). Note that the category 1, 2 and 3 levels in many cases are exactly the same as respectively the category A, B and C levels for dwellings in EN 15251.

The indoor climate requirements can be specified by stating the required level (1, 2, 3 or 4) for each parameter as performance targets for the design team of architects and engineers. The category levels can also be used as reference levels e.g. when doing measurements in existing buildings.

3.1 HOW TO USE THE DIFFERENT CATEGORIES?

When (re)designing a dwelling or housing complex the basic idea is to select an ambition level separately for each of the four aspects, e.g. 'category 2' for noise and acoustics. Then for all sub-aspects within that aspect the same end quality is the target, which means e.g. using the category 2 value for system noise, the category 2 level for façade insulation etc.

When evaluating existing buildings sometimes different quality levels might be found in different rooms. This is for example the case when noise measurements show that the system noise level in bedroom 1 is at category 1 level, in bedroom 2 at category 2 level and in the living room and the kitchen again at category 1 level. In that case the 'worst room wins' meaning that the overall quality of the building as a whole for the aspect noise and acoustics is category 2.

3.1 Indoor Climate categories

Concerning the time factor: the requirements presented should be met a minimum of 95% of occupied time. So e.g. overheating during periods that occupants are not at home is not taken into account. The main question is: how is the indoor climate quality when people are at home? Of course, deciding what a good assumption is for occupancy hours, needs special care and should be decided upon taking the type of occupants into account (e.g. occupancy time in a housing complex for the elderly is very different from that in an apartment complex for young, urban professionals without kids).

CATEGORY	EXPLANATION
1.	Suitable in case of a high level of expectation. Is recommended e.g. for spaces occupied by very sensitive and fragile persons with special requirements (sick people, very young children, the elderly etc.).
2.	Suitable in case of an above-average level of expectation. Should be used as standard level for new dwellings and larger renovations.
3.	Suitable in case of a moderate level of expectation. Could be used as a reference for more limited renovations or as a reference value when measuring in well performing existing buildings.
4.	Suitable in case of a limited level of expectation. May be used as reference level when measuring in older existing buildings.

Table *– Description of the applicability of the different indoor climate categories (based on: EN 15251:2007)*

3.2 Light & view out

3.2 LIGHT & VIEW OUT
Adequate lighting and especially well designed daylight penetration provides an array of health benefits to building occupants. Furthermore, it positively influences mood and well-being. Just like an optimized view out. Therefore, residences should allow for optimal daylight and attractive views to the outside in such a way that electric lighting during daytime is hardly necessary, providing opportunities for reducing overall lighting energy consumption.

Note that no requirements concerning lighting (artificial light) are included in the table above. This is because this aspect in residential situations is not under the influence of building designers: the end-users themselves decide what kind of lighting to put in and how to control this.

Also no requirements are presented for the reflectance and color of e.g. floors, ceilings and walls. Obviously, this influences visual comfort inside (lighter colors result in better daylight penetration), but also this aspect is not (or hardly) under the influence of designers.

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Daylight factor	The amount of daylight in a room is evaluated through average daylight factor levels at horizontal work plane (table) height (around 0,8 m). Daylight factors are calculated with a validated daylight simulation program. The daylight factor is looked at on room level. For the main rooms that used during the day (living and activity zones such as a living room, work space, dining room, kitchen, bedroom, or child's play room) the minimum daylight factor is: 1: DF > 5% on average 2: DF > 3% on average 3: DF > 2% on average 4: DF > 1% on average Reference: CIBSE 2002 Code of Lighting. Circulation zones and bathrooms should preferably have access to daylight.
	Direct sunlight availability	For minimum one of the main habitable rooms room sunlight provision should be available between fall and spring equinox: 1: At least 10% of probable sunlight hours. 2: At least 7,5% of probable sunlight hours. 3: At least 5% of probable sunlight hours. 4: At least 2,5% of probable sunlight hours. Shading device should allow for direct sunlight to be excluded if desired. The evaluation is made according to British Standard BS 8206-2:2008 "Lighting for buildings - Part 2: Code of practice for daylight".
Qualitative	View out	Windows should be located to offer the best possible views to the exterior environment (sky and surroundings). Windows providing a view to the outdoors should have high visible transmittance and should distort the colour of daylight as little as possible. A shading device obstructing the least amount of view out while fulfilling the shading requirements should receive preference. This is especially true for windows in living rooms, study rooms, kitchens and other rooms that are used a lot during daytime.

3.3 Thermal environment

3.3 THERMAL ENVIRONMENT

A pleasant thermal environment is essential for a comfortable home. Adequate thermal comfort, both in summer and winter, boosts the mood, increases performance and in some cases (e.g. in houses for the elderly) prevents and alleviates diseases. Buildings should minimize overheating in summer and optimize indoor temperatures in winter without unnecessary energy use. Where possible, use good building physics and clever solar shading instead of overcomplicated and energy intensive mechanical systems.

Note that no maximum variation between highest and lowest temperature has been included as this is not considered relevant for residential buildings. To allow for night cooling and the use of the accumulative properties of the building mass, there should be the possibility for a substantial variation.

Note that the adaptive upper temperature limits for offices from Annex A2 of EN 15251:2007 were used. This is because that standard does not give any specific adaptive upper limits for residences. Generally, office occupants have less adaptive opportunities: clothing adjustment possibilities are more limited than in residences and the use of operable windows in offices is normally more restricted. So using the adaptive office requirements for dwellings result in a conservative approach and maybe some overestimation of overheating risks in living rooms, bedrooms etc.

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Maximum operative temperature in summer	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). The indoor operative temperature is looked at on a room level. In dwellings 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: it goes up during warmer periods. For living rooms, kitchens, study rooms, bedrooms etc. in dwellings without mechanical cooling systems and with adequate opportunities for natural (cross or stack) ventilation the maximum indoor operative temperatures are: 1. $T_{i,o} < 0.33 \cdot T_{rm} + 20.8°C$ 2. $T_{i,o} < 0.33 \cdot T_{rm} + 21.8°C$ 3. $T_{i,o} < 0.33 \cdot T_{rm} + 22.8°C$ 4. $T_{i,o} < 0.33 \cdot T_{rm} + 23.8°C$ Where Trm is the Running Mean outdoor temperature as defined in Annex A2 of EN 15251:2007. The indoor temperature limits only apply in periods with an outside Trm of 12 °C or more ('during summer'). For livingrooms etc. in residential buildings with mechanical cooling systems (e.g. 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: $T_{i,o} < 28°C$ Reference: EN 15251:2007. Preferably for bedrooms (especially at night time) a 2°C lower value should be used than indicated above as people are more sensitive to high temperatures when sleeping or trying to fall asleep. Also, in kitchens one periodically can allow for higher temperatures than indicated e.g. during cooking activities.
	Minimum operative temperature in winter	To determine whether thermal comfort is guaranteed in winter a dynamic thermal simulation tool is used. The indoor operative temperature is looked at on a room level. 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 indoor temperature limits only apply in periods with an outside Trm of 12°C or less ('during winter').
Qualitative	Individual control	Winter: It should be possible to adjust the temperature at room level according to momentary needs, e.g. with adjustable thermostats. Summer: It should be possible to manually influence the thermal conditions in each room, e.g. by opening windows and adjusting solar shading (if present). In case of mechanical cooling systems, it should be possible to adjust the temperature at room level, e.g. with adjustable thermostats. Climate system interfaces (e.g. wall thermostats) should be intuitive and simple.
	Draught	Ventilation openings, including windows, ventilation grilles and mechanical ventilation devices, must be located and detailed so that discomfort caused by draught is minimised. Adjustability (e.g. of operable windows and ventilation grilles) is an important issue to take into account in this context.

3.4 Indoor air quality

3.4. INDOOR AIR QUALITY

Good indoor air quality can prevent mucous membrane irritation, asthma and allergy, as well as cardiovascular and other diseases. It also helps to avoid odour problems which in turn positively affect overall well-being. Buildings should provide good air quality for the occupants while minimizing energy use e.g. for ventilation. Where possible natural ventilation should be used or so called hybrid systems (combination of natural and mechanical ventilation) as these systems generally are more user-friendly and give less risk for internal pollution of the ventilation air.

Note that no specific requirements are given for minimum relative humidity level. In residences (also those in colder climates), humidification of indoor air is usually not needed to prevent 'dryness' complaints and irritation of eyes and airways. Those kind of complaints can be more effectively avoided by securing adequate fresh air supply, with good source control (e.g. not using polluting materials) and with dampness/ mould control in wet rooms (extraction ventilation). See also the indoor air quality strategy described in EN 15251:2007.

Also note that not all indoor air related potential health hazards are dealt with in the table above. For example: in certain areas (e.g. with rocky undergrounds) Radon exposure requirements should be added. Other examples that might apply locally include (ultra) fine particles in areas with mediocre outdoor air quality (e.g. close to busy highways) and legionella in dwellings with certain types of ventilation and cooling systems.

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Standard fresh air supply	Fresh air supply can be evaluated by looking at CO_2-concentrations indoor at room level during occupancy. CO_2 is a good indicator for the amount of bio effluents, pollutants from humans, in the air. Hourly values and maximum levels of CO_2-concentration preferably are determined with a dynamic simulation tool. Assuming standard occupancy rates (e.g. two persons in a master bedroom) and standard CO_2-production per person assumptions. The limit values for indoor CO_2-concentration in living rooms, bed rooms, study rooms and other rooms with people as the dominant source and that are occupied for prolonged periods are: 1. 350 ppm above outdoor CO_2-concentration 2. 500 ppm above outdoor CO_2-concentration 3. 800 ppm above outdoor CO_2-concentration 4: 1100 ppm above outdoor CO_2-concentration Reference: EN 15251: 2007. Note that this standard also gives the fresh air supply rates (e.g. for living rooms and bedrooms) in $l/s/m^2$ that are needed to comply with the CO_2-requirements above.
	Minimum fresh air supply	When dwellings are unoccupied a minimum air change rate of 0.2 ACH should be maintained, to remove pollution from material emissions, appliance emissions, etc.
	Dampness	In rooms with periodic damp production peaks (esp. kitchens, bathrooms and toilets) sufficient extraction must be guaranteed to avoid dampness and mould problems. The minimum exhaust air flow in these 'wet rooms' should be as specified in national building codes or guidelines. If these are not available, see EN 15251: 2007 for example design values (in 3 categories) for exhaust air flows in kitchens, bathrooms and toilets. Dampness problems furthermore are prevented by a building envelop that is well insulated and free of cold bridges. In order to prevent internal or surface condensation that could lead to mould growth and a deterioration of the air quality inside. Comply, also in renovation project, as much as possible with local building requirements for thermal insulation and e.g. temperature factor.
Qualitative	Individual control	It should be possible to manually influence the air change rate in the rooms (especially living room, kitchen and bed rooms), e.g. by opening windows. In case mechanical ventilation is installed, it should be possible to adjust the airflow rate at 3 or more levels. Additionally, the ventilation may be demand-controlled based with CO_2 or humidity sensors.
	Low-emitting building materials	Building components and materials (e.g. processed wood products, paints and sealants) should be evaluated with regards to chemicals emitted from them, and low-emitting components are preferred. Preferably use Indoor climate labeled materials. For example materials with the Danish Indoor Climate label, the Finnish M1 label, the German AgBB or GUT label or the French AFFSET label.
	User instruction	In case of complicated ventilation systems or unusual user restrictions (e.g. concerning interior materials that can be introduced by the occupants) an easy to understand 'indoor air user instruction' should be provided. This document should explain how systems work and what is expected of end-users (e.g. as far as operation of systems and maintenance is concerned).

3.5 Noise and acoustics

3.5 NOISE AND ACOUSTICS

An optimal acoustical environment positively affects health, well-being and performance of building users. In extreme cases, exposure to noise can even cause or aggravate cardiovascular diseases. Dwellings should be designed to minimize exposure to noise (e.g. from traffic outside or from inside installations) and to optimize overall acoustic quality of living spaces.

Note that design values for reverberation time are not included because of the fact that in dwellings the acoustics of living rooms, bedrooms etc. are largely decided upon by the dwellers themselves (they decide about curtains, type of floor covering etc).

Also, for practical reasons the table above only includes requirements for sound insulation for façades in relation to traffic and industry noise. Of course interior noise (e.g. from people in adjacent rooms) can also be a problem. So in many situations it is advisable to also use requirements for internal sound insulation (e.g. of floors and room partitioning walls).

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Inside system noise	Exposure to system noise (e.g. from ventilation or heating systems) is determined with a sound pressure measurement as described e.g. in ISO 410: 1998. For living rooms, kitchens, etc. the limit values for inside system noise are: 1: 25 dB(A) 2: 30 dB(A) 3: 35 dB(A) 4: 40 dB(A) For bedrooms, study rooms and other rooms that need extra quietness the limit values for inside system noise are: 1: 20 dB(A) 2: 25 dB(A) 3: 30 dB(A) 4: 35 dB(A) Reference: EN 15251:2007. In case an adjustable mechanical ventilation system is in place e.g. with a 3 position user button than the noise level can exceed the limits mentioned above. But only in the higher position (nr. 3) and only when that ventilation flow in that higher position is much higher than the minimum ventilation flow as described in the indoor air quality table.
	Sound insulation façade	Inside airborne noise levels due to traffic, industry noise etc. from outside the dwelling are determined with a standardised calculation method e.g. based on EN-ISO 717. The airborne sound insulation of the façade takes into consideration average and maximum outside noise levels due to e.g. traffic and industry. The overall (calculated) sound insulation of the façade (and roof construction) is such that background outside noise levels inside are a maximum of: 1: 25 dB(A) 2: 30 dB(A) 3: 35 dB(A) 4: 40 dB(A) (Assuming that calculations are done with operable windows and outside doors closed.)
Qualitative	Acoustic privacy	It should be possible to perform noisy activities without disturbing neighbours. So preferably at least one room (and its entrance door) should be extra sound insulated.

Sources and tools: *EN 15251, Breeam, EN ISO 410, EN ISO 717, EN ISO 7730, CIBSE 2002 Code of Lighting.*

4.0 Environment

4.0 ENVIRONMENT
The challenges we face regarding the environment are global. Global environmental resources are under pressure from over-consumption and pollution. However, to tackle these challenges most efficiently we need to consider carefully the regional as well as the local aspects too.

When developing an Active House it is important to ensure the fact that these three levels of challenges are considered. It is important in order to ensure a new generation of buildings and products which aim to have a positive impact on the environment.

In order to ensure that the Active House enters into this positive spiral for the environment and health for humans, it is important to consider carefully how building materials and resources are used. Furthermore, the regional and site-specific ecological and cultural context needs to be considered too.

THE KEY PARAMETERS ARE:

- Resource & Emissions:
  - Consumption of non-renewable energy resources
  - Environmental loadings from emissions to air, soil and water
  - Fresh water consumption and waste water treatment[1]
- Response to cultural and ecological context

In order to ensure, that the requirements for the global and the local are met, they are listed in the forms as qualitative and quantitative requirements. The impact of the Active House buildings is placed in one of four categories from 1 to 4, with category 1 as the highest level of performance.

When the design team of engineers and architects have to define the level of ambition for the building these four categories (1, 2, 3 or 4) can be used for each parameter. The level of ambition expresses a predicted performance, and will differentiate from the actual performance in use.

[1] *The parameter 'Solid and liquid wastes' has been discussed and will be incorporated in a later enlarged version.*

Evaluation:
When evaluating the performance of the buildings, it is important to consider the consumption of energy resources and the emissions to air, soil and water through a Life Cycle Assessment according to ISO 14040. The building's life cycle is considered in the following life stages (as in CEN TC 350):
- Production of building materials
- Construction processes
- Operation of the building & maintenance of the building construction and fabric
- End of life of building materials

In building an Active House transport and site processes may be omitted. However, at least all major building components should be considered. Major building components means:
- outside walls
- roofs, slabs
- foundation
- windows and doors
- inner walls
- major technical component (heat generators etc.)

The estimated service life of the building should be assumed according to local standards. Active House suggests assuming 75 years. The estimated service life of all building components should be assumed according to local standards and experiences.

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.

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

Other impact categories may be added.
The results need to be normalized per m2 usable space and monitored every year. The benchmarks below are subject to change as they need to be proofed in the testing phase.

4.1 Consumption

4.1 CONSUMPTION OF NON-RENEWABLE ENERGY RESOURCES
The production and use of energy are closely connected to the ecological, economic and social sustainability in society as a whole, and hence they are very important to consider in an Active House.

As it is a goal in Active House to use primarily renewable energy, it can be necessary – for a period of time – to take in a limited input of non-renewables. When calculating how to use these, they have to be calculated into primary energy factor. The aggregated energy-equivalent values of the following resources: black coal, brown coal, mineral oil and uranium, represent the primary energy input. Also defined in Construction Materials Manual as:

“The primary energy input of a building material describes the quantity of energy media (resources) required for the production and use of the material. In doing so, we distinguish between renewable and non-renewable primary energy.”[1]

The unit describing the potential impact of a building material with reference to its use of energy /fossil fuels is Megajoule (MJ), described as:. *“100 MJ corresponds to the calorific value of 2.8 l heating oil.”*[2]
The quantification is kWh, which can be transformed to MJ by dividing with 3.6 (*3,6MJ is 1kWh).*

[1, 2] *Construction Materials Manual, Hegger, Birkhäuser München. p.98*

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Minimization of non-renewable primary energy consumption during building's life cycle. Measure: Primary energy (non- renewable) consumption in kWh / m²*a. Primary Energy = PE	1. The consumption of non-renewable PE during life cycle is below -150 kWh/ m²*a 2. The consumption of non-renewable PE during life cycle is below 15 kWh/ m²*a 3. The consumption of non-renewable PE during life cycle is below 150 kWh/ m²*a 4. The consumption of non-renewable PE during life cycle is below 200 kWh/ m²*a
	Maximization of the percentage of renewable primary energy during building's life cycle. Measure: Primary energy (renewable) consumption in kWh / m²*a.	1. The consumption of renewable PE during life cycle is below -25 kWh/ m²*a. The renewable PE is 40% of the total primary energy used during life cycle. 2. The consumption of renewable PE during life cycle is below 0 kWh/ m²*a. The renewable PE is 30% of the total Primary energy used during life cycle. 3. The consumption of renewable PE during life cycle is below 12,5 kWh/ m²*a. The renewable PE is 20% of the total PE used during life cycle. 4. The consumption of renewable PE during life cycle is below 25 kWh/ m²*a. The renewable PE is at least 10% of the total PE used during life cycle.
Qualitative	Minimization of non-renewable primary energy consumption during building's life cycle (*for existing buildings, the energy contained is not accounted for)*.	1. A complete LCA was done considering the entire life cycle. The results were used to optimize the design. 2. A simplified LCA according to the minimum requirements was done considering the entire life cycle. The results were used to optimize the design. 3. No LCA was done, but the consumption of non-renewable PE is reduced by the efficient use of energy carriers during operation (e.g. CHP) and by using lightweight constructions. 4. No LCA was done, but the consumption of non-renewable PE is reduced by the efficient use of energy carriers during operation (e.g. CHP).
	Maximization of the percentage of renewable primary energy during building's life cycle (*for existing buildings, the energy contained is not accounted for)*.	1. A complete LCA was done considering the entire life cycle. The results were used to optimize the design. 2. A simplified LCA according to the minimum requirements was done considering the entire life cycle. The results were used to optimize the design. 3. No LCA was done, but the consumption of non-renewable PE is reduced by the use of renewable energy carriers during operation and by using renewable building materials. 4. No LCA was done, but the consumption of non-renewable PE is reduced by the use of renewable energy carriers during operation.

4.2 Environmental loadings

4.2 Environmental loadings from emissions to air, soil and water
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 an Life Cycle Assessment it is important to know and consider the different impact categories of these emissions, which each address one environmental effect. They are explained here:

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 and ecosystems as well as material welfare. The global warming potential groups together gases in relation to the impact of carbon dioxide (CO_2).

Ozone depletion potential (ODP)
Ozone (O_3) occurs as a trace gas in the stratosphere (10-50km height) and absorbs the 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 enhanced, with potentially harmful impacts on human health, terrestrial and aquatic ecosystems, for example causing DNA-damages, cancer, especially skin cancer, and eye affections, 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 CCl_3F).

Photochemical ozone creation potential (POCP)
A higher concentration of ozone in the troposphere (0-15 km height), 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 combustions. The latter are 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 domestic 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. For example, 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 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 fertilizers, nitrogen oxides of combustion engines, domestic wastewater, industrial waste and wastewater. Plants in excessively fertilised soils exhibit a weakening of their tissue and a lower resistance to environmental influences. In aquatic ecosystems increased biomass production may lead to a depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition. This may result in fish kills 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 to become nitrite, which is toxic for human-beings. The eutrophication potential groups together the substances in comparison to the impact of phosphate (PO_4-3).

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Minimization of global warming potential (GWP) during building's life cycle.	Global warming potential (GWP) in kg CO_2-eq. / m^2*a 1. The global warming potential (GWP) during life cycle is below -30 kg CO_2-eq. / m^2*a 2. The global warming potential (GWP) during life cycle is below 10 kg CO_2-eq. / m^2*a 3. The global warming potential (GWP) during life cycle is below 40 kg CO_2-eq. / m^2*a 4. The global warming potential (GWP) during life cycle is below 50 kg CO_2-eq. / m^2*a
	Minimization of ozone depletion potential (ODP) during building's life cycle.	Ozone depletion potential (ODP) in kg R11-eq. / m^2*a 1. The ozone depletion potential (ODP) during life cycle is below -5,6E-06 kg R11-eq. / m^2*a 2. The ozone depletion potential (ODP) during life cycle is below 5,3E-07 kg R11-eq. / m^2*a 3. The ozone depletion potential (ODP) during life cycle is below 3,7E-06 kg R11-eq. / m^2*a 4. The ozone depletion potential (ODP) during life cycle is below 6,7E-06 kg R11-eq. / m^2*a
	Minimization of Photochemical ozone creation potential (POCP) during building's life cycle.	Photochemical ozone creation potential (POCP) in kg C_2H_4-eq. / m^2*a 1. The photochemical ozone creation potential (POCP) during life cycle is below 0,000 kg C_2H_4-eq. / m^2*a 2. The photochemical ozone creation potential (POCP) during life cycle is below 0,0040 kg C_2H_4-eq. / m^2*a 3. The photochemical ozone creation potential (POCP) during life cycle is below 0,0070 kg C_2H_4-eq. / m^2*a 4. The photochemical ozone creation potential (POCP) during life cycle is below 0,0085 kg C_2H_4-eq. / m^2*a

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Minimization of acidification potential (AP) during building's life cycle.	Acidification potential (AP) in kg SO_2-eq. /m^2*a 1. The Acidification potential (AP) during life cycle is below 0,010 kg SO_2-eq./ m^2*a 2. The Acidification potential (AP) during life cycle is below 0,075 kg SO_2-eq./ m^2*a 3. The Acidification potential (AP) during life cycle is below 0,100 kg SO_2-eq./ m^2*a 4. The Acidification potential (AP) during life cycle is below 0,125 kg SO_2-eq./ m^2*a
	Minimization of eutrophication potential (EP) during building's life cycle.	Eutrophication potential (EP) in kg PO_4-eq. /m^2*a 1. The Eutrophication potential (EP) during life cycle is below 0,0000 kg PO_4-eq./ m^2*a 2. The Eutrophication potential (EP) during life cycle is below 0,0055 kg PO_4-eq./ m^2*a 3. The Eutrophication potential (EP) during life cycle is below 0,0085 kg PO_4-eq./ m^2*a 4. The Eutrophication potential (EP) during life cycle is below 0,0105 kg PO_4-eq./ m^2*a
Qualitative	Minimization of environmental impact due to emissions during building's life cycle.	1. A complete LCA was done considering the entire life cycle. The results were used to optimize the design. 2. A simplified LCA according to the minimum requirements was done considering the entire life cycle. The results were used to optimize the design. 3. No LCA was done, but emissions are reduced by the efficient use of renewable energy carriers during operation (e.g. CHP) and by using lightweight constructions and renewable or recycled building material. 4. No LCA was done, but emissions are reduced by the efficient use of renewable energy carriers during operation (e.g. CHP).

4.3 Freshwater consumption

4.3 FRESHWATER CONSUMPTION AND WASTE WATER TREATMENT
The depletion and scarcity of the global natural water 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 fresh water is saved it results in a waste water saving as well and both topics are part of this specification. The fresh water consumption can be reduced by installation of water saving tabs, use of grey or rain water for toilets and gardening and the installation of easy to clean surfaces.

	PARAMETER	CRITERIA AND EVALUATION METHOD
Quantitative	Minimization of fresh water consumption during building's life cycle.	1. For all installation water saving units were used. 2. For two to three installations water saving units were used. 3. For Tabs, showers or toilets water saving installations were used.
	Use of grey or rain water.	1. Rain water is used for watering the garden. Grey or rain water is used for toilets as well. Treated grey or rain water is used for the washing machine. 2. Rain water is used for watering the garden. Treated grey or rain water is used for the washing machine. 3. Rain water is used for watering the garden. Grey or rain water is used for toilets as well. 4. Rain water is used for watering the garten.
	Easy to clean surfaces.	1. >80% of the floors inside the building are easy to clean or do not need to be cleaned with water. 2. >60% of the floors inside the building are easy to clean or do not need to be cleaned with water. 3. >40% of the floors inside the building are easy to clean or do not need to be cleaned with water. 4. >20% of the floors inside the building are easy to clean or do not need to be cleaned with water.

4.4 Cultural and ecological context

4.4. CULTURAL AND ECOLOGICAL CONTEXT

The local building culture and behavior in and around them as well as traditions, climate and ecology are all fundamental issues when designing an Active House. They are the so-called cultural and ecological context. It is important to be able to improve the building's exterior and interior relations to the cultural and ecological site-specific context.

When evaluating an Active House an Environmental Impact Assessment needs to be carried out, based on preliminary assumptions, observations and analyses about the site characteristics, local architectural typology, climate, materials, handcraft as well as an understanding of local standards of society and behavior and traditions.

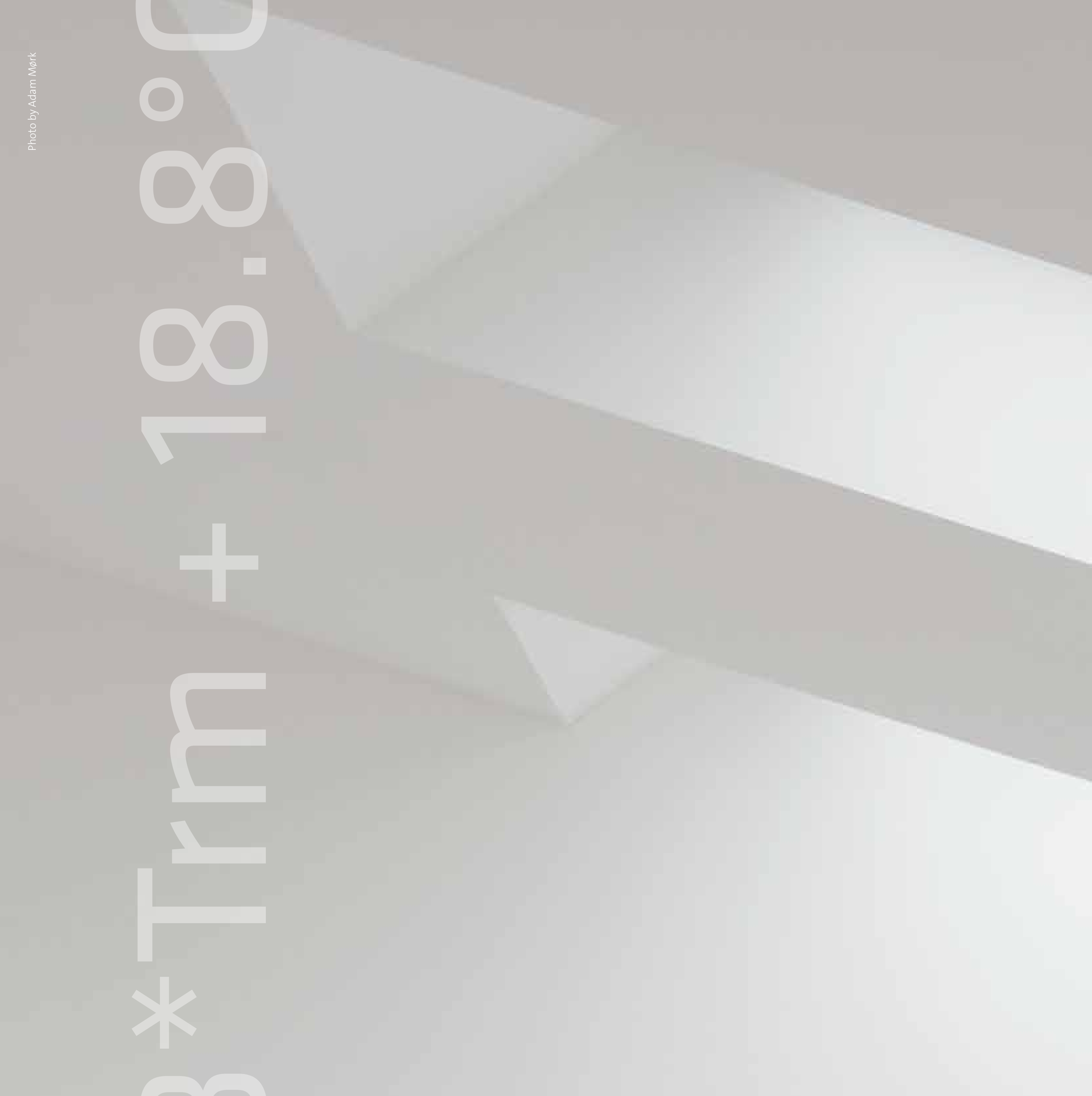
The qualitative parameters are to be regarded as recommendations and input for the process, and not as design decisive parameters. Therefore the qualitative parameters opposite are formulated as questions that encourage the design team, builder and user to optimize potentials regarding the values related to the cultural and ecological context.
The work method remains with the planning team, the result is what counts.

The goal is that these quality-oriented criteria are identified, analyzed and that support the definition and agreement of a strong objective for the building. These criteria can be evaluated qualitatively through registration and definition of how local characteristics and culture are analyzed and incorporated in the design/objective of the building (quality orientated planning).

Response to cultural and ecological context:

	PARAMETER	CRITERIA AND EVALUATION METHOD
Qualitative	Building traditions	How is the design of the building reflecting a relationship with the regional building traditions? E.g. regional materials, architectural typology and handcraft is analyzed and used as design parameters?
	Climate	How is the design of the building adapting to the potentials and constrains of the local climate? E.g. creating private outdoor spaces with a comfortable climate and access to sunlight that encourage to healthy active outdoor living?
	Street- and landscapes	How does the design impact on existing street- and landscapes? E.g. provision for children to play safely outside the house and supporting the public outdoor space for local behavior, needs and tradition?
	Infrastructure	How is the infrastructure supporting a healthy, comfortable and ecological transportation? E.g. connection and distance to nearest public transport for commuting, distance to school and supermarket and the possibly of easy and safe use of bicycles?
	Ecology and land use	How is the building optimizing the relationship with the local ecology and land use and at the same time minimizing environmental risks? E.g. maximizing surface for seepage of rainwater, minimizing use of land, preserving fauna.
	Climate changes	How is possible risks caused by climate changes (storms and flooding) identified and limited in the design of the building and landscape?

Sources and tools: *ISO 14040. ISO 14025. CEN TC 350*



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ACTIVE HOUSE
Network and knowledge sharing

Active House is a vision of buildings that create healthier and more comfortable lives for their occupants without impacting negatively on the climate.

Comments, input and recommendations to the Active House specification are welcome and can be sent to **activehouse@activehouse.info** or uploaded at the Active House homepage at **www.activehouse.info.**

The website is an online community where you can upload cases with buildings that show the development towards Active Houses, as well as upload relevant reports and other knowledge sharing documents.

Companies, organizations and institutes can become member of the Active House Alliance. The purpose of the alliance is to develop Active House to become the future standard for buildings. Register yourself at **www.activehouse.info.**

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