SPECIFICATION AND ASSESSMENT CRITERIA OF ACTIVE HOUSES

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Summary

The Energy Performance of Buildings Directive (EPBD) requires that Member States shall implement nearly Zero-Energy Buildings for domestic buildings before 31 December 2020. A common methodology has not been developed, and European countries have to define their own interpretation of nearly Zero-Energy Buildings (NZEB).

Active house is one interpretation of NZEB, and it is based on a combination of international methods, supplemented with national calculation methodologies, so it can be adopted throughout the world. Active houses are buildings which are designed with a holistic and balanced focus on comfort, energy, and environment, and they should have ambitious goals set within each of these overall themes. Active houses can be residential, commercial or public buildings, and the concepts apply to new buildings as well as to renovated existing ones. The definition of the concepts is developed within an international association, the Active House Alliance. The alliance was founded in June 2010.

According to the Active house vision, active houses should strive for a positive energy balance, they should provide healthy and comfortable occupancy for the users, and their overall environmental impact should be positive when viewed over the life cycle.

Central to the alliance is the Active house specifications which set qualitative and quantitative targets within 9 areas of performance indication. The indicators are graded on a four-level scale, so active houses can be characterized by their signature in a radar plot. As the Active house specifications are adjusted based on national conditions and climate, they can be used throughout the world.

The paper gives an overview of the 9 indicators, and it will illustrate by means of an example house how the radar plot makes it possible to give an appraisal of the building.

Keywords: building specifications, energy, comfort, environment, holistic appraisal.

1 The Active house specifications

“Active house” and its specification is a global vision on what makes a sustainable building. The specifications are based on nine different performance indicators which are distributed over the three main themes: Comfort, Energy, and Environment. Each performance indicator is rated on a scale which gives a possibility for up to 4 credits. It is not necessary that an active house scores the maximum 4 credits on all indicators, since even the minimum level represents a certain level of rather good solutions.

Compared to other systems for rating of buildings (e.g. Passive houses, LEED, BREEAM or DGNB), the Active house specifications are less stubborn on setting very strict limits on the quantitative criteria, e.g. there is some room for national adjustment and interpretation. It is the intention that the calculation shall be based on a combination of the international methods, with a view to national conditions. And the specifications include a number of qualitative criteria. Essential for an active is the holistic view that ample performance is ensured across all areas: comfort, energy and environment.

The specific performance indicators and their criteria are listed below. The criteria explained in this paper are for residential buildings – both new and renovated. Criteria will be developed also for other building types.

1.1 Quantitative performance indicators

1.1.1 Comfort

EN 15251 [1] is used as reference for several of the criteria under the comfort theme.

Daylight

Optimal daylight conditions and view to the outside are required. Scales are defined for two quantitative criteria: the average daylight factor, and the availability of direct sunlight. For instance, an average daylight factor below 1 % is not permissible, since this is the threshold to obtain the lowest score, 4. An average daylight factor of at least 5 % is required to obtain the highest score, 1.

Thermal environment

Quantitative criteria are stipulated regarding the maximum and minimum operative temperatures for summer and winter conditions, respectively. The requirement to maximum indoor temperature depends on the system chosen, where mechanical ventilation has specific figures and natural ventilation systems have other figures depending on outdoor conditions as described in EN 15251. In 95 % of the occupied time, the indoor temperature may not exceed $0.33*T_m + 20.8$ °C in order to reach the highest score 1, for naturally ventilated rooms, and it must not exceed $0.33*T_m + 23.8$ °C for the lowest score, 4 (T_m being the running mean outdoor temperature).

Indoor air quality

Quantitative criteria are set up using CO_2 concentration as an indicator. Looking to fulfilment in 95 % of the time, the criteria are for instance that CO_2 concentration should not be more than 1100 ppm higher than the outdoor concentration to obtain a score 4, while this difference must not exceed 350 ppm to obtain a score 1.

1.1.2 Energy

The methodology from the Energy Performance of Buildings Directive [2] is used as reference, supplemented with the national methodology for calculation the energy performance of buildings. A holistic view is adopted to the use of energy. An active house is very energy efficient, and the energy should be supplied from renewable sources either on the plot/at the house, or from the nearby community/grid. The following three performance indicators for energy are observed.

Energy demand

This comprises space heating, hot water, ventilation, air conditioning, technical services and electricity for lighting. The threshold to obtain a score 4 is an annual energy demand of

120 kWh/m^2, which is mainly relevant for renovation projects, whereas a building must a have demand less than 40 kWh/m^2 in order to obtain a score 1.

Energy supply
An active house must produce some of its own energy from renewable and CO_2 neutral sources. To obtain the highest score 1, the criterion is that the same amount of energy must be produced as what is used by the building. The minimum threshold for score 4 is that 25 % of this energy is produced.

Primary energy performance
The use of primary energy equals the energy demand subtracted the energy produced by or near the building times an energy conversion factor, which is based on national regulation that considers how energy is produced. A building which has a primary energy use of less than 0 kWh/m^2 is rated with the score 1. A primary energy use of more than 30 kWh/m^2 is permitted with a score 4, which is a category reserved for existing buildings, i.e. new buildings must use less than 30 kWh/m^2 and thus will score 3 or better.

1.1.3 Environment

The overall ambition is that an active house should have an as positive impact as possible on the environment. A number of performance indicators are used in this respect.

Environmental load
Quantitative indicators considered are Global warming potential; life cycle energy consumption; ozone depletion potential; photochemical ozone creation potential; acidification potential; and eutrophication potential. The averages of the individual scores of the above indicators, gives the final score between 1 and 4 for the environmental load.

Freshwater consumption
An indicator is used for how much the consumption of fresh water has been reduced compared to a national average consumption. An active house shall use at minimum 10 % less water to reach the lowest class 4, and 50 % less than national averages in order to obtain a score of 1.

Sustainable construction
Quantitative assessment is carried out regarding the content of recyclable building material and responsible sourcing. To reach the highest score of 1, more than 50 % of the materials (by weight) shall be recyclable, and regarding responsible sourcing, 100 % of wood and more than 80 % of other materials must be certified material.

1.1.4 Radar plot

All quantitative indicators are used to describe the level of ambition and gathered on a radar plot, such as shown in Fig. 1 which gives an easy to assess signature of the building.

The radar is a method to display the ambition with the building and the 9 parameters. It can also be used to display the monitored values of the building, and when the building is inhabited, it will be a tool for dialogue about expected performance and follow up.

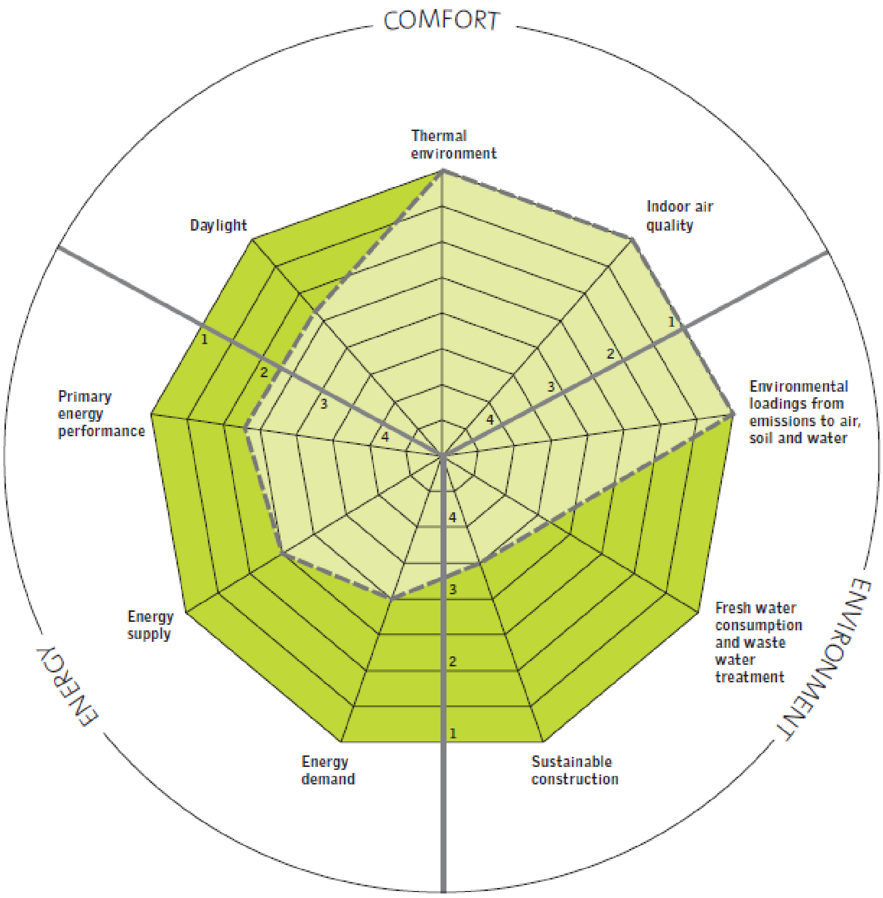

Fig. 1 *Radar plot of a building*

1.2 Qualitative performance indicators

23 qualitative performance indicators are defined within the same nine areas as for the quantitative indicators. In addition, some 17 further qualitative indicators are defined within the areas of "Noise and acoustics", "Energy validation on site", "Building management" and "External context and accessibility".

2 Future Active House – Trondheim

"Future Active House" [3] is the name of the second Active House build in Norway. It is located near the town of Trondheim. The region is surrounded by mountains and located about 600 km from the Arctic Circle. The weather ranges from mild, light summers to winters of heavy snowfall and long nights.

Fig. 2 *The "Future Active House" in Norway*

Future Active House Norway is a 165 m^2 single family house in two stories with basement. It has been built by Tore Ligaard AS, with design by Brendeland & Kristoffersen Architects and energy consulting by Teknoconsult AS. The construction has been carried out by SSBygg AS.

The challenge was to create a house where architecture and energy efficiency are balanced, without sacrificing the qualities of light, air and interaction with the environment. Future Active House seeks to meet these challenges. Based on the active house principles, the building is designed to be both a showcase of innovative solutions as well as a modern family home.

In their attempt, the architects draw on inspiration from both past and present. "The ground floor is the private zone, with bedrooms and the big bathroom. The main room on the first floor is essential and inspired by traditional Norwegian architecture, where houses often have a large, central room with light coming in from a hole in the roof."

In order to evaluate the efficiency of Future Active House and its equipment, energy consumption data and other performance measures will be collected the first two years when the house is occupied.

2.1.1 Comfort

The amount of daylight in a room is evaluated through average Daylight Factor (DF) at a horizontal work plane height of 0.8 m. The higher the DF, the more daylight is available in the room. Rooms with an average DF of 2 % or more are considered daylit. A room will appear strongly daylit when the average DF is above 5 %.

Daylight simulations and calculations of average daylight factor for the main rooms have been summarized in Tab. 1 and visualized for first floor in Fig. 3.

Tab. 1 *Average daylight factor for the main rooms of the "Future Active House"*

Room	Daylight factor
Hall (Ground floor)	2.6 %
Master Bedroom (Ground floor)	3.9 %
Bedroom 1 (Ground floor)	3.2 %
Bedroom 2 (Ground floor)	3.2 %
Living + Kitchen (First floor)	8.3 %
Guest room (First floor)	5.1 %

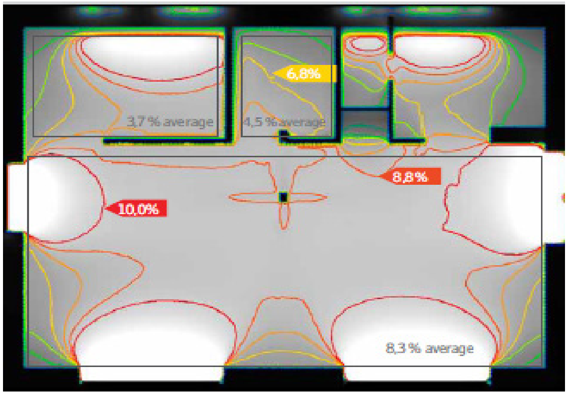

Fig. 3 *Visualisation of daylight factors in rooms on the first floor of the "Future Active House"*

Mechanical ventilation during Winter **Natural ventilation during Summer**

Fig. 4 *Ventilation principles used winter and summer in the "Future Active House"*

The thermal comfort in the building is optimized by use of energy efficient solutions, which during winter keeps the heat inside the building and the comfort temperature high, whereas the building is being shaded and naturally ventilated during summer, and thereby cooled without use of energy.

The air quality in the building is secured by a hybrid ventilation system, see Fig. 4. In winter, mechanical ventilation with heat recovery is used, while in summer natural ventilation is used through motorized façade and roof windows. Both the mechanical and natural ventilation systems are controlled by a building management system based on air quality data from sensors that monitor humidity, temperature and CO_2 levels in the house.

2.1.2 Energy

Future Active House includes a range of energy-efficient technologies and follows the principles of Trias Energetica to minimizing energy consumption through the low energy design and optimizing the use of renewable sources in energy supply.

The house is classified with the Norwegian energy rating "A", which means that its annual consumption must not exceed 79 kWh/m^2 for all energy used in the building. An average detached house in Norway consumes approximately 170 kWh /m^2.

Energy consumption is kept low thanks to a number of initiatives with wall U-value of 0.12 W/m^{2}K, roof U-value of 0.10 W/m^{2}K, foundation U-value of 0.14 W/m^{2}K and low-energy windows with U-values between 0.7 and 1.0 W/m^{2}K. The heating system is optimized and automatically controlled by a KNX system [4] which monitors and manages building equipment and functions such as sunscreens, ventilation and temperature control. Correct operation and control can bring significant energy savings (40–60%) to all these functions.

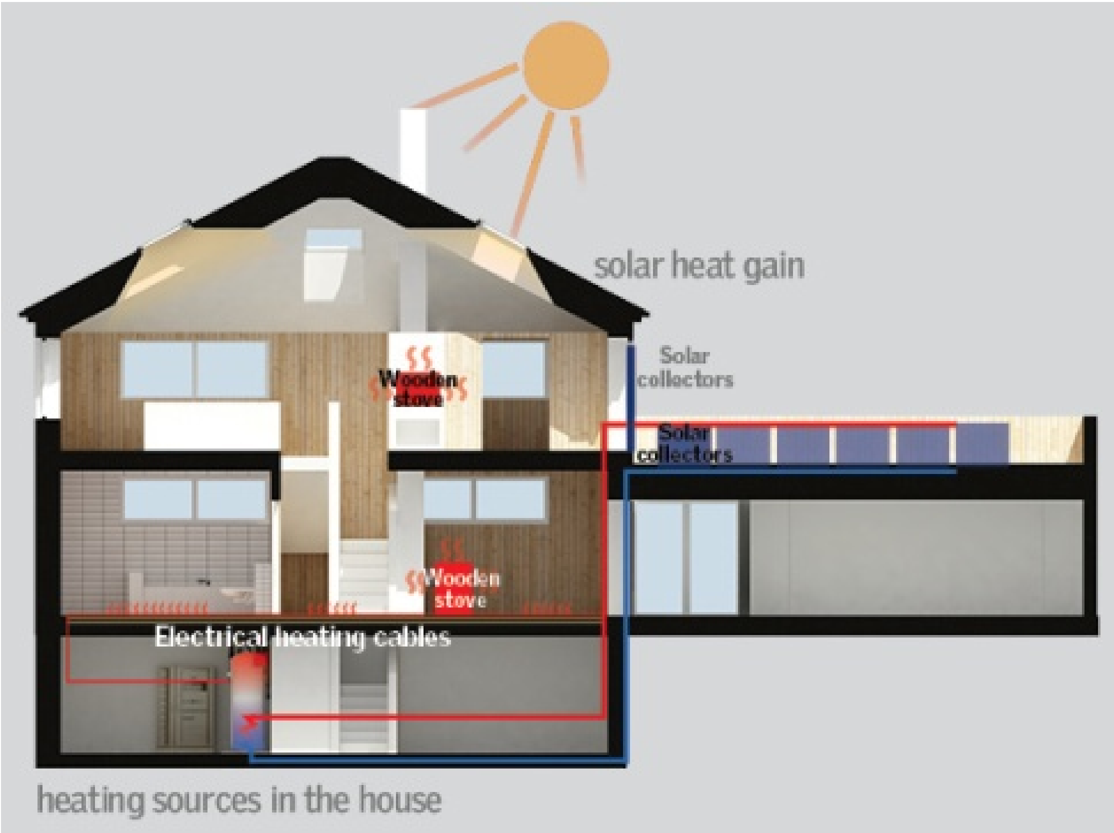

Fig. 5 *Heat sources in the "Future Active House".*

The main heating system is floor heating in the entrance area and bathroom in the ground floor, supplemented with a fireplace on the ground floor and a fire insert on the first floor. The first floor is mainly heated by the heat from the ground floor, supplemented with solar gains from the windows.

18 m^2 solar collectors provide 30 % of the energy demand and supply energy to domestic hot water and the primary water based heating system in ground floor. When needed electricity will be connected with the energy-efficient heater supplying domestic hot water and heating cables in the floors in the corridor and bathroom.

The ventilation is a hybrid ventilation system, which during winter is based on mechanical ventilation with heat recovery of 80 %, and during summer it is based on natural ventilation.

In order to evaluate the efficiency of Future Active House and its equipment, energy consumption data and other performance measures will be collected the first two years when the house is occupied.

2.1.3 Environment

Buildings should have as little environmental impact as possible. The main focus on the environment for "Future Active House" has been to use local materials as far as possible.

Furthermore, it is part of the vision that the environment friendly house must be easily adapted to regional conditions.

The estimated service life of the building is assumed to be 75 years as recommended in the Active House specification. All major building components have been considered. The LCA results for each building component have been multiplied by a safety factor of 1.1 to cater for materials in the building components, which are not included in a simplified LCA calculation.

The following life stages are considered:

- Production of materials and components.
- Operation of the building and replacement of building materials and components.
- End of life of building materials and components.

The environmental impact data of materials and components are generic data from the German material database Ökobaudat and the European material database ESUCO. The electricity energy mix is specific for Denmark, while the gas energy mix used is from the ESUCO database.

The active house LCA spreadsheet has been used to calculate the LCA.

Tab. 2 *Environmental assessment of the "Future Active House"*

Environmental parameter	Result
Minimization of global warming potential (GWP) during building's life cycle.	The global warming potential (GWP) during life cycle is 19 kgCO2-eq./m^2a
Minimization of building energy consumption during all life cycle	The consumption of non-renewable PE during life cycle is 143 kWh/m^2a
Minimization of ozone depletion potential (ODP) during building's life cycle.	The ozone depletion potential (ODP) during life cycle is 1.13E-06 kg R11-eq./m^2a
Minimization of photochemical ozone creation potential (POCP) during building's life cycle.	The photochemical ozone creation potential (POCP) during life cycle is 0,0027 kg C2H4-eq./m^2a
Minimization of acidification potential (AP) during building's life cycle.	The acidification potential (AP) during life cycle is 0,044 kg SO2-eq./m^2a
Minimization of eutrophication potential (EP) during building's life cycle.	The eutrophication potential (EP) during life cycle is 0,0074 kg PO4-eq./m^2a

3 Discussion and conclusions

Experience from a number of European and international projects are gathered and presented by members of the Active House Alliance, including projects under the very cold climates of Norway, Russia and Canada, as well as projects under the central European and North American climate. The projects can be followed at www.activehouse.info.

Generally the experience has shown that the ambition of obtaining nearly Zero-Energy Buildings, and the ambition to obtain a CO_2 neutral society can be reached globally without compromising on the quality and comfort in buildings.

As the Active house specification is based on international and national methodologies, and can be adapted in different countries with different climate, it can become the methodology for implementation of nearly Zero-Energy Buildings. A full edition of the specifications is available on www.activehouse.info.

The national development and requirement to nearly Zero-Energy Buildings are needed to focus on energy savings and CO_2 reduction. However, it will also give authorities a possibility to implement requirements to comfort in buildings and to environment. This is recommended, since in the future it is the balanced performance of a building that will be important.

An example of an active house is the Norwegian "Future Active House". The experience with "Future Active House" and with other demonstration projects shows that the ambition with nearly Zero-Energy Buildings and the ambition to reach a CO_2 neutral society can be reached globally without compromising on the quality and comfort in buildings by use of the active house vision.

The actual use of energy, when the building is occupied is often higher than the calculated performances of a building. Often there is a difference between 50 and 100 % and it is relevant to discuss if intelligent control/management like the KNX in "Future Active House" can reduce this figure and to what extent intelligent control/management shall be used.

References

[1] EN 15251. *Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*. CEN, European Committee for Standardization. 2007.

[2] DIRECTIVE 2010/31/EU *on Energy Performance of Buildings, annex 1.*

[3] Further info about future Active House at: http://www.framtidensaktivhus.no/english/

[4] KNX is a worldwide standard for Home and Building Control, supported by a wide range of international companies within domestic buildings: http://www.knx.org/knx/what-is-knx/