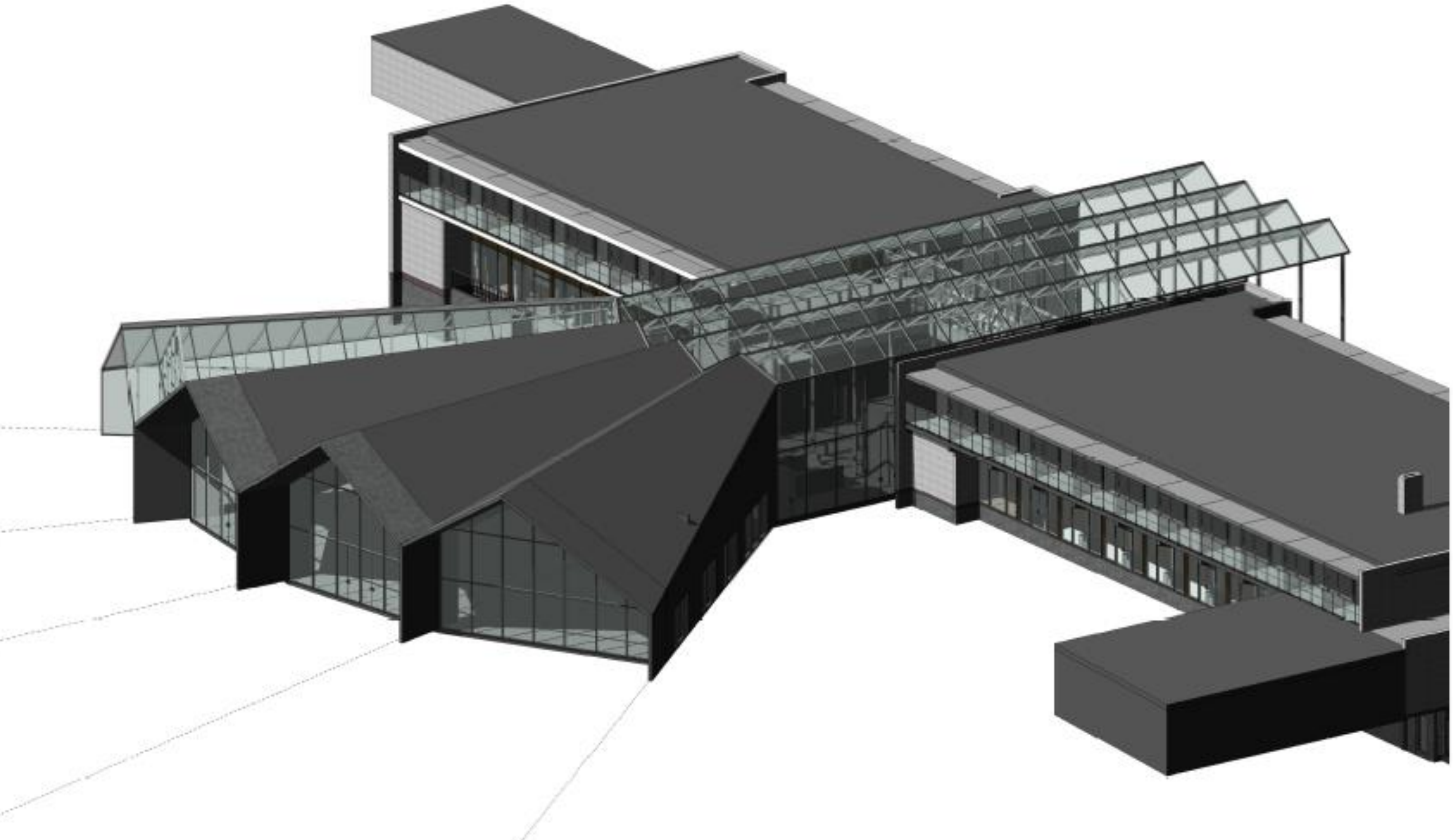
TEKNOLOGISK
INSTITUT

# Active House Evaluation_rev01

## GREEN SOLUTION HOUSE



Teknologisk Institut

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|---|---|
| Titel: | GREEN SOLUTION HOUSE |
| Prepared for: | VELUX A/S |
| Prepared by: | Teknologisk Institut<br>Kongsvang Allé 29<br>8000 Aarhus C<br>Bæredygtigt Byggeri<br><br>November 2013 – February 2015 |
| Authors: | Pernille Brændstrup Andersen<br>Amdi Schjødt Worm |
| Basis for report and calculations: | ACTIVE HOUSE – the specifications for residential buildings 2nd edition (marts 2013) and corresponding tools |

## CONTENT

## 1. Introduction

Technological Institute, Sustainable Construction has been commissioned to evaluate "Green Solution House" according to the Active House Specifications.
The evaluation includes the hotel rooms as they are before renovation, the hotel rooms after renovation and the new building (N) that should incorporate the conference room.
The assignment was given to Sustainable Construction autumn 2013 and the evaluation report has been finished February 2015.

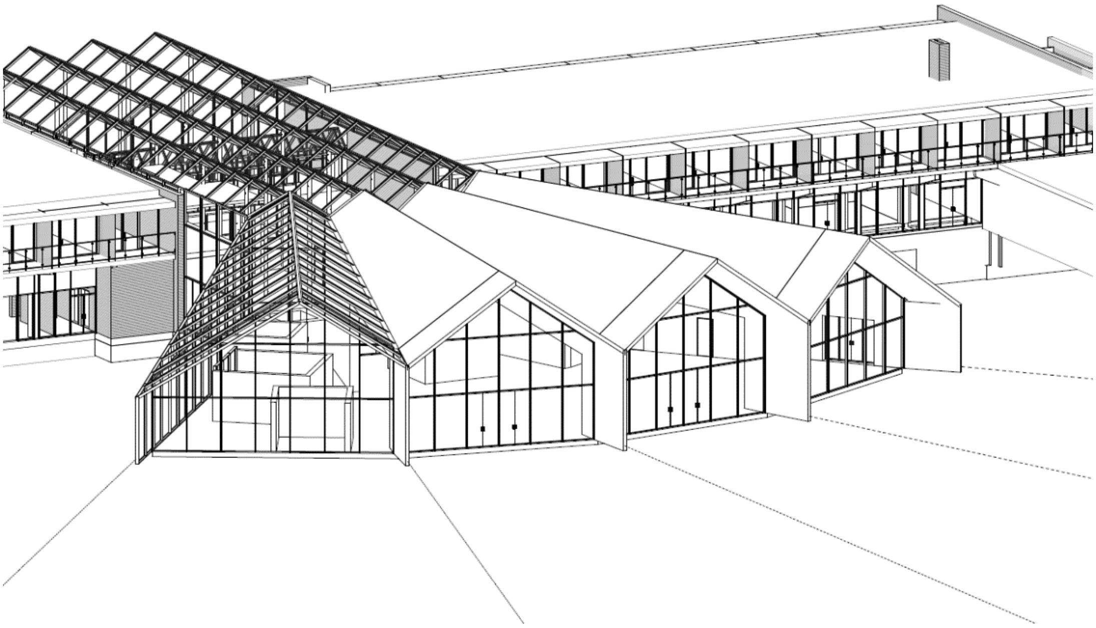


*Figure 1: New design concept*

## 2. Active House radars

Active house radars have been developed for the following:

- Building A – before renovation
- Building A – after renovation (with and without renewable energy from district heating)
- Building N

The results of the radars are elaborated further below.

## 3. Building A – before renovation

The evaluation of Building A includes Hotel Room A1.33. The radar in Figure 2 shows the performance of the building before renovation.
The result is typical for an older non-renovated building, where there has been no focus on energy performance, environmental impact and comfort.

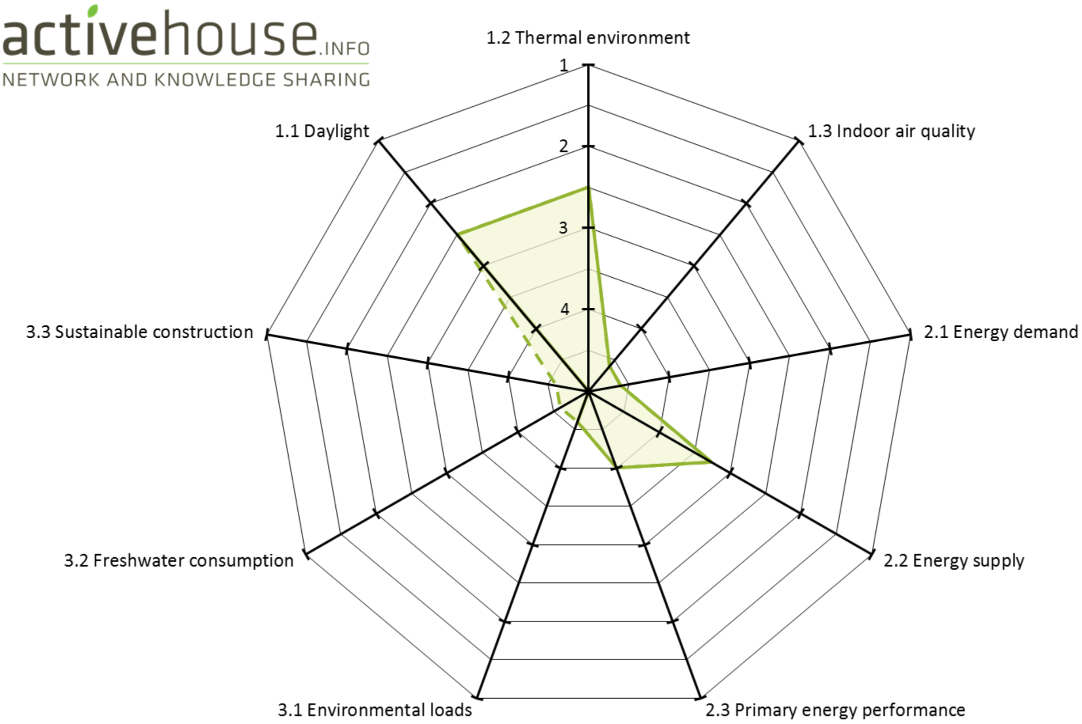



*Figure 2: Result of AH evaluation of Building A before renovation without renewable energy from district heating*

The best score achieved is the Daylight score due to a large window-area in the façade and the height of the façade (window)-relation to the depth of the room. The window area also ensures a medium score for probable sunlight hours. Thermal environment also achieves a medium score due to large overhangs (2m depth), and a massive construction.

The score for Energy supply is a results of the renewable part of the district heating (45%) at Rønnes district heating supply.

The poor performance on environmental load is mainly caused by the high energy demand in the use phase of the building.

## 4. Building A – after renovation

The evaluation of Building A includes Hotel Room A1.33. The evaluation is based on the "smart rooms – performance".

Radar 1 (Figure 3) shows the result of the evaluation of Building A based on the design concept where the amount of locally produced renewable energy for the building has been taken into account.

In radar 2 (Figure 4) the locally produces renewable energy has not been taken into account. The evaluation has been performed based on the information given by the project group (arch, ing, and partners). DRY 2013 file has been used as climate conditions for both the energy and indoor comfort evaluations.

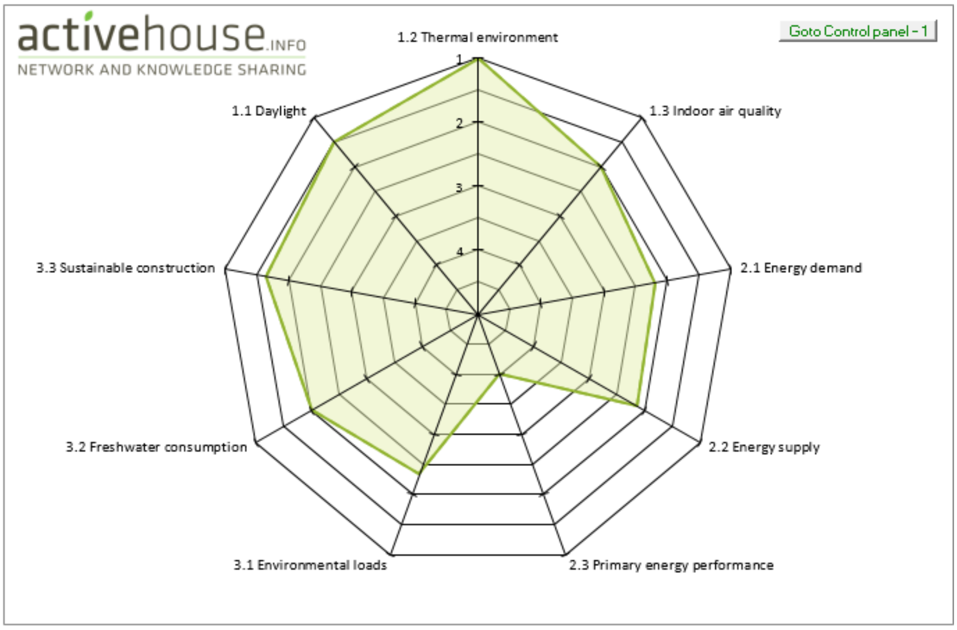



*Figure 3: Active House radar for Building A, first floor, Green Solution House with renewable energy supply from district heating*

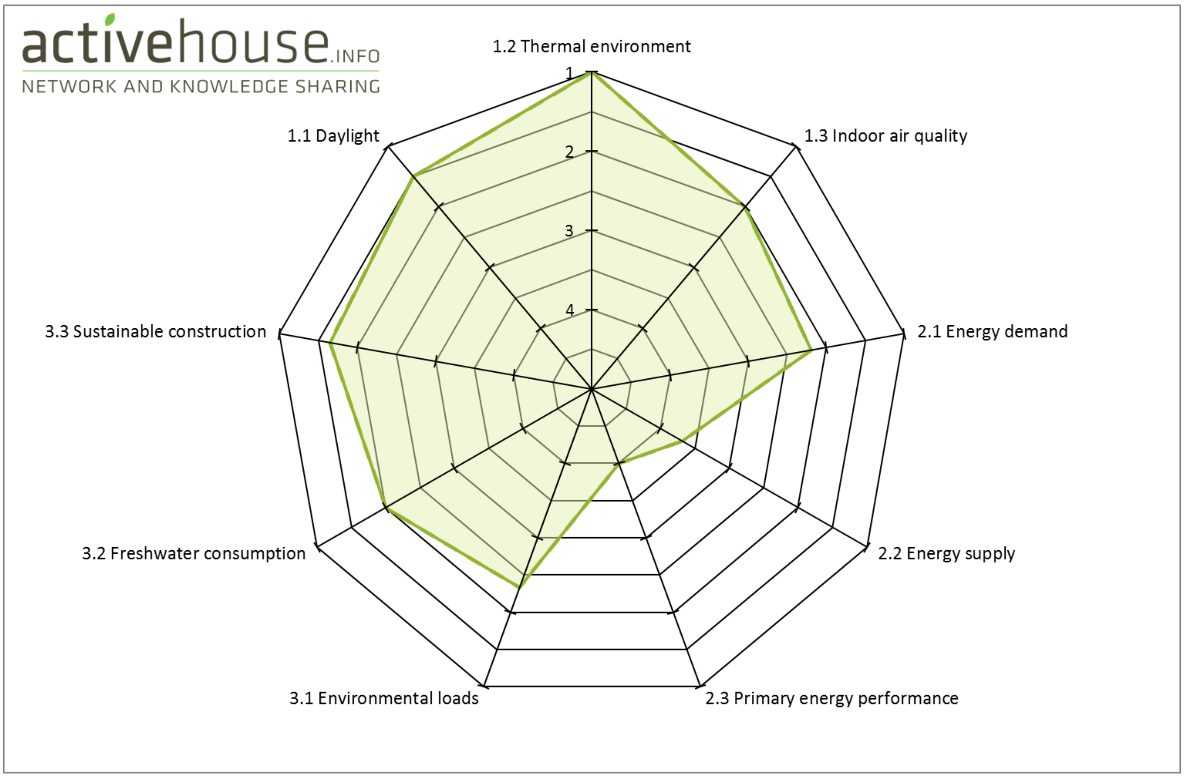


*Figure 4: House radar for Building A, first floor, Green Solution House without renewable supply from district heating*

## 1.1 Daylight

Daylight was simulated using VELUX Daylight Visualizer. Daylight was simulated for one of the "Smart rooms" – hotel-room. The score is 1,5 and is an average of the scores of daylight factor ( Score 2) and probable direct sunlight hours (score 1)

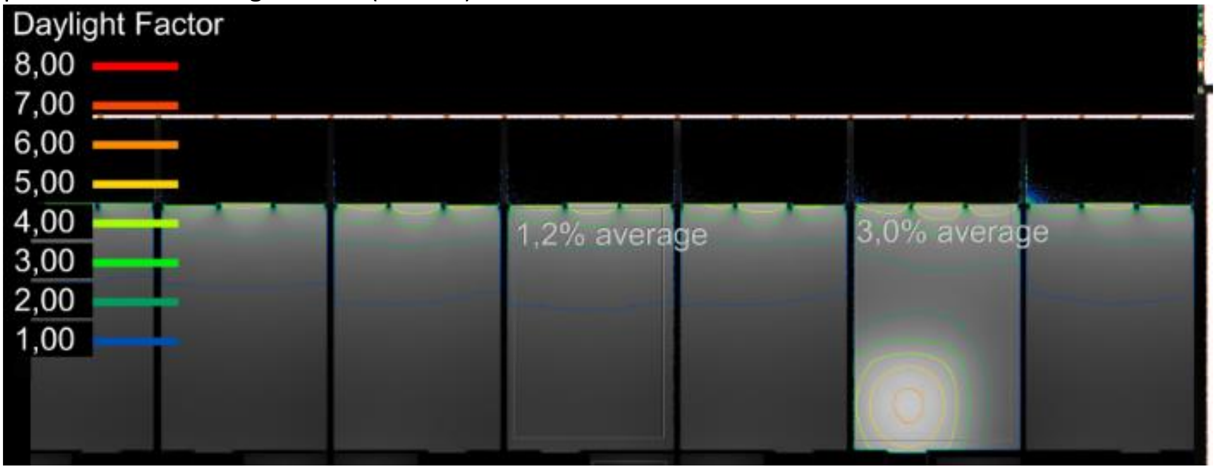


*Figure 5 Daylight simulations - hotel rooms before and after renovation*

## 1.2 Thermal environment

The score of the thermal environment is 1,0. Half of the hotel rooms are oriented southwest and half of them northeast. The simulation was performed on a south-vest oriented room (worst case). The score is simulated based on a setup with two persons in the room. The large overhang along with the possibility of using natural ventilation during the façade and through the skylights and the heavy constructions all together results in the best achievable score.

### 1.3 Indoor air quality

The score for the indoor air quality is 2,0. The score is a result of the function of the fresh air supply system. The air supply system contains a heat recovery unit. In addition to the mech. Ventilation, the room is equipped with a flat-roof window that makes it possible to use natural ventilation during the summer period.

Taking the natural ventilation into account the score is 1,0 during wintertime and also 1,0 during summertime (with one person in the room). With two persons in the room, the score is 2,0 during the wintertime and 1,0 during the summertime (total score of 2). The simulation was performed with mechanical ventilation rates according to “byggeprogrammet”. The score in the radar is based on two persons present in the room.

### 2.1 Energy demand

The score of the energy demand is 2,2. The score is a result of the added insulation on the facades and roof combined with mechanical ventilation with heat recovery and the existing windows have been replaced with new 3-layer glazed windows. The building-design also contributes to the low energy demand due to its compact and rectangular shape. The calculation of the energy demand is based on the assumption that all hotel rooms eventually will be renovated as the smart-rooms.

### 2.2 Energy Supply

The energy supply is a combination of heat from the solar thermal panels and the district heating system. The heat supply is considered being 45% renewable as documented in
http://www.brk.dk/Borger/Bolig/Forsyning/Documents/Varmeplan%20Bornholm%202013.pdf

With renewable energy supply from the district heating system the score is 2,1. Without RE for district heating the score is 3,7.

### 2.3 Primary energy performance

The score for the primary energy performance is “4.0”. The PV production only contributes to the electricity demand of building N. Only the Solar thermal productions contributes to the PE performance of building A. Even though the renovation have focused on reducing the energy demand, it has not been possible to achieve a PE performance level that combined with the production from the solar thermal system results in a score better than 4.0. The primary energy demand has been calculated to 79,1 kWh/m2/year and the primary energy production has been calculated to 21 kWh/m2/year leading to a total PE performance at 58 kwh/m2/year (>30kWh/m2/year)

Reading this result it is important to remember that renewable energy supply from the grid cannot be taken into account in the PE performance according to the EU directive on energy and buildings and national Danish building legislation.

### 3.1 Environmental loads

An LCA calculation is carried out with the score 2,3 as result. Generally 2.3 is a good result for the LCA-calculation. The score is achieved because of the fact that the building is part of the renovation. The construction-parts with high environmental footprint such as concrete and partly also the insulation has been reused in the refurbished building and only contributes to the LCA calculation by its "End of Life" – loads. In combination with the energy demand (for a refurbished building at least) the score is a result of good environmental focus.

### 3.2 Fresh water consumption

The score of the fresh water consumption (2,0) is based on the assumption, that water saving toilets and fixtures have been used. It has also been confirmed by the hotel owner, that special water saving bath-fixtures will be used in the future.

### 3.3 Recyclable content and responsible sourcing

The score of recyclable content is 1,3 as the amount of recyclable building material has been calculated to 44%. The score of responsible sourcing is 2,0. The score of FSC is based on the assumption that suppliers deliver the minimum required content of FSC timber, which is 70%. Since the project partners have had a large focus on this issue and specifically asked the material-manufactures to deliver the appropriate documentation all wooden products are FSC or PEFC products.

Regarding the EMS it has been calculated that 72 % (by weight) of the new material has been delivered from companies with EMS-documentation. In total the score is 2,0.
The score of the 3.3 indicator is a combination of two scores – the score for recyclable content and responsible sourcing. The average score is 1.7.

### 4.1.1. Combined radars Building A

To show the improvements from "before renovation" to "smart room" both radars have been combined into one. This radar is shown in Figure 6 below.

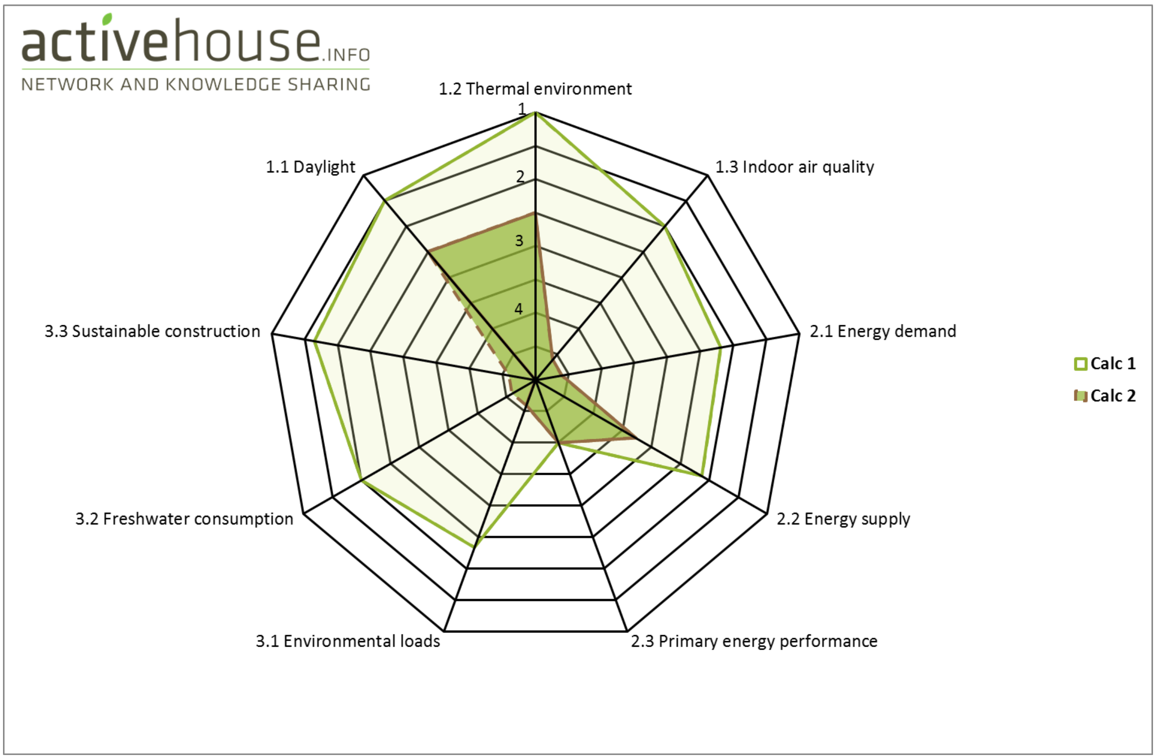



*Figure 6: Result of AH evaluation before and after renovation*

Calc 1 shows the result of the evaluation before renovation of building A. Calc 2 shows the radar before renovation of building A.

## 5. Building N

The evaluation of Building N includes the conference room for indoor climate and the conference room and the facilities for the conference room for the energy calculations and LCA. The radar is based on calculations done based on drawing materials and descriptions from tender and communication with Rambøll, Steenbergs Tegnestue and GXN respectively.

As the conference-room covers most of the area in the extension, the radar is based on simulations of this room. The result of the evaluation is shown in Figure 7.

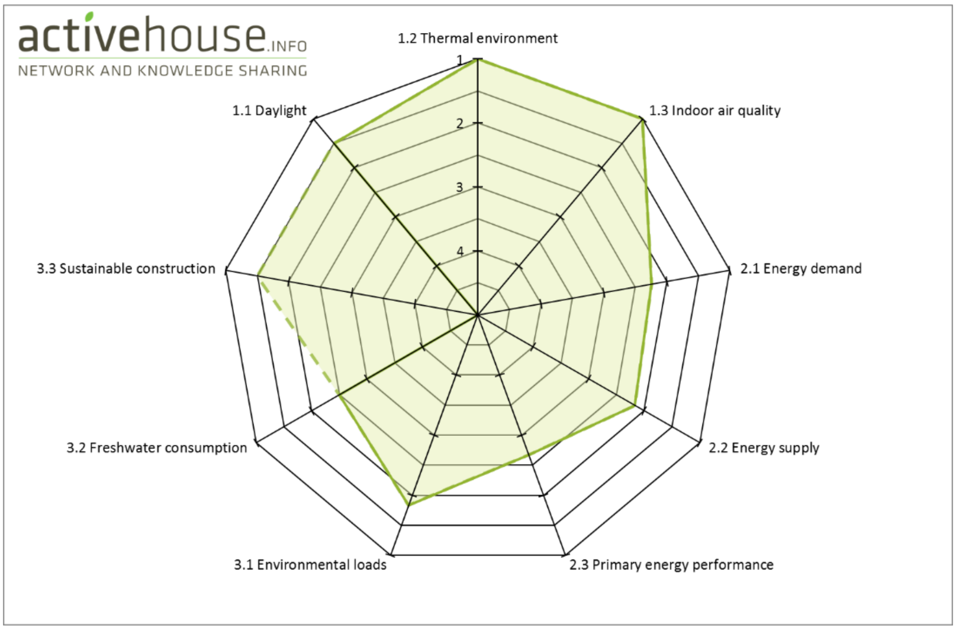



*Figure 7: Result of AH evaluation of Building N*

## 1.1 Daylight

The score for daylight is 1,5. This score is an average of the daylight factor in the whole conference room (6,6% equal to score a 1) and the probability of direct sunlight (7,5% equal to a score 2). As the room mainly has large window area facing north / northeast / northwest the amount of direct sunlight is limited which reduces the overall score for daylight. The access of direct sunlight is however improved by the direct sunlight through the roof windows.

## 1.2 Thermal environment

The thermal indoor climate achieves a score of 1. This is primarily due to an effective mechanical ventilation system with mechanical cooling. Also it is possible to use the windows for natural ventilation. The natural ventilation alone would in this case be sufficient to ensure a satisfactory indoor climate in periods where the conference room is only partly used.

The evaluation is done based on the asumption that maximum 200 people are present at the same time. The number of hours with a temperature above 25,5°C (equal to a score 1) is 34. As the overall hours of use is 2352 hours this is less than 2% of the hours of use. This means the criteria is fulfilled more than 95% of the occupant time and the room therefore scores 1,0.

The heating system is capable of keeping a temperature of 21°C and the criteria for minimum temperature is fulfilled for all hours of use.

## 1.3 Indoor air quality

The score for indoor air quality is 1. The score is based on a presence of 200 people in the room. The score is achieved with a mechanical ventilation system dimensioned to keep a CO2 level less than 850PPM. This equals the criteria for a score 1,0.

## 2.1 Energy demand

The score for energy demand is 2,2. The score is achieved by a combination of a well-insulated building envelope and windows / roof windows with a good energybalance. The high level of daylight and the mechanical ventilation system with a low SEL-value contributes to a low energy demand for electricity. In this calculation the usage for the mechanical cooling systems is also included.
If natural ventilation is used more than assumed this will reduce the demand for electricity for mechanical cooling . This should however not compromise the thermal indoor climate. It should be noted that the energy demand in Figure 8 below has been calculated using the assumptions and requirements of SBI 213 and it should therefore not be used to compare to measured performance.

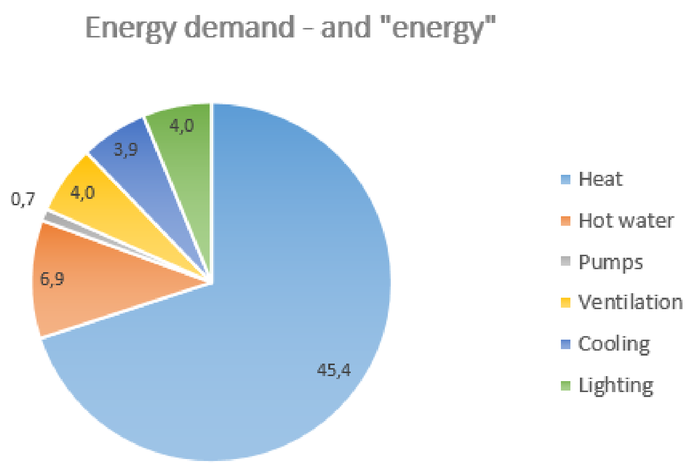



*Figure 8: Distribution of energy demand ini kWh/m2/år*

## 2.2 Energy Supply

The energy supply is district heating. On Bornholm 45% of the district heating comes from renewable sources. This has been taken into consideration in the radar of building N. Furthermore a photovoltaic system with a calculative performance of app. 10.000 kWh pr. year is established. This gives a total of 71% of energy demand covered by renewable sources which equals a score of 2,2.

## 2.3 Primary energy performance

The score for primary energy performance is 2,7.
The score for primary energy performance is calculated by multiplying the energy demand and the energy production with the respective energy factors. As the building is designed for LEK2015 (Low energy class 2015, Danish Building Regulations) electricity is multiplied by 2,5 and heat by 0,8 (both demand and production). This gives a primary energy performance of 10,1 kWh/m$^2$/year which equals a score 2,7.

## 3.1 Environmental loads

The environment load of the building is calculated for materials and use over 50 years. For the construction it is mainly the major construction elements that have been included in the calculation (outer walls, roof, slabs and foundation).  20% has been added to this equaling a typical load from technical installations and inner walls (in this project the inner walls are primarily heavy constrctions).

Usage of the building is included in the calculation based on Be10-calculations and converted to environmental loads via the average environmental load for district heating in Denmark.

## 3.2 fresh water consumption

Usage of water is based on values for a standard hotel as described in "*Energihåndbogen*".
In GSH a number of initiatives have been done to reduce the amount of freshwater consumption, including water saving toilets and fittings. Altogether this gives a score of 2,5.

## 3.3 Recyclable content and responsible sourcing

The score for sustainable construction is based on assumptions of the major constructions and the possibility to recycle the materials used for these. The assumptions is qualified after conversation with Lasse Lind, GXN and Steenbergs Tegnestue.

The constructions are in general built in a way that makes it easy to separate the individual materials after dismantling. Furthermore flued laminated timber has been used for the bearing construction. This reduces the environmental load and increases the recycling potential.

Finally the non-bearing part of the outer walls have been built of light constructions which helps decrease the environmental load.

The project group have made an effort to collect documentation for FSC/PEFC and EMS certification of products as possible.

The score for recyclable content is 1 as min. 50% of the materials by weight have been recycled or is expected to be recycled at the end of life. Responsible sourcing has a score of 2. This is based on 80% of the timber having a FSC/PEFC or equivalent certification. Furthermore 50% of the materials used are judged to have an EMS certification. This gives an overall score for responsible sourcing of 1,5. It should be noted that the overall considerations are judgements which is indicated by the dashed line in the radar in Figure .

## Annex I: Comments to AH Radar – Building A before renovation

### AI-1 - Daylight

Daylight simulations was made by VELUX.

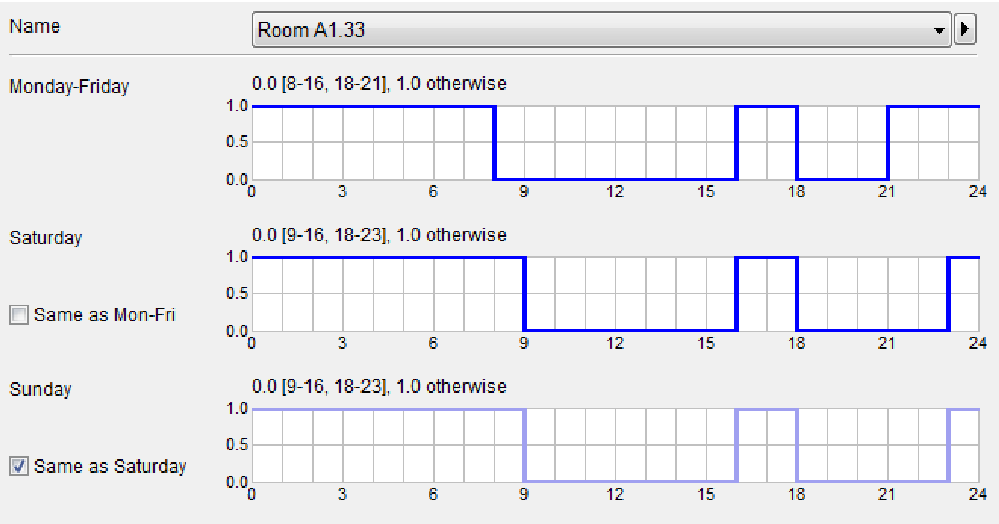
### AI-2 – Indoor climate simulations

The program used is VELUX Energy and Indoor Climate Visualizer Pro, version 2.1.
The following room was simulated:

- Room A1.33

This note describes important assumptions when doing the simulations.
The note concerns both the situation before and after the renovation.

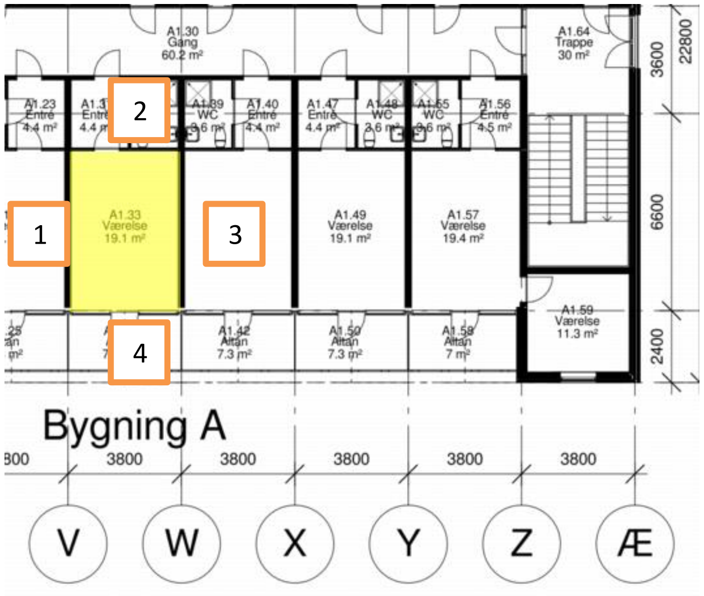
GENERAL SETTINGS:
The assumed presence in the room is the same in the before and after situation.
The room is assumed to be occupied by two persons following the schedule shown in the figure below. 1 in the graph equals the presence of two people in the room.



Assumptions made when creating the model in EIC in the before and after situation are listed below.

Before After

Physical placement of room A1.33 is shown in the figure below.




Area covered by the simulation is marked yellow in the figure above.
Wall 1, 2 and 3 are considered adiabatic.
Wall 4 is subjected to outdoor climate
The floor in the room is adiabatic.

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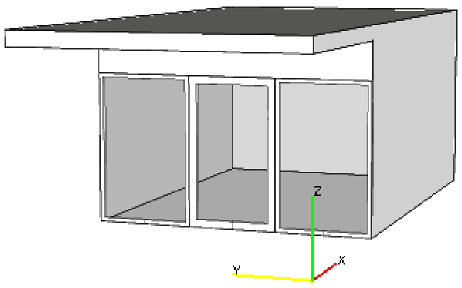
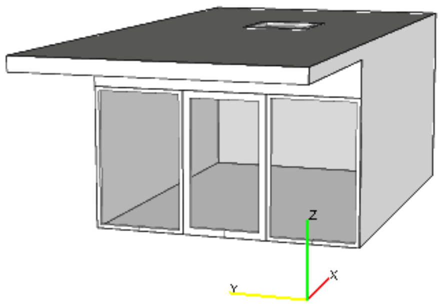
Construction before renovation



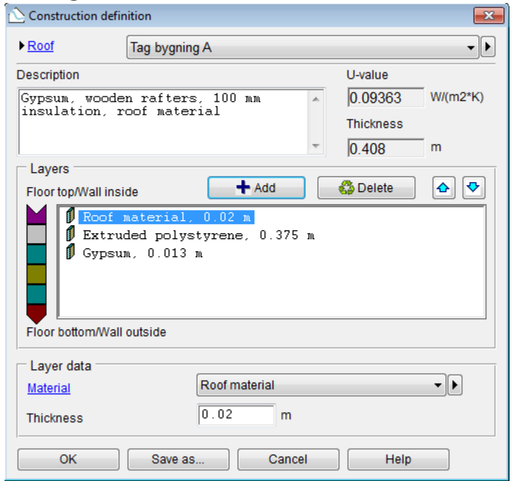

The exterior wall is modelled with a generic wall with U-value = 0.39 W/m$^2$K (European value).
The roof is modelled with a U-value = 0.35 W/m$^2$K.

The leakiness of the building is: Average building from 1980

Construction after renovation




The exterior wall is modelled with a generic wall with U-value = 0.217 W/m$^2$K (See energy calculation input data)
The roof is modelled with a U-value of 0,09W/m$^2$K according to the figure below:




The leakiness of the building is: Average building from 2005

## Windows and doors

Glazing in windows before renovation are made as custom panes based on the table below:

| | From final design concept | | Assumed based on U- and g-values | | 45° | 0° |
|---|---|---|---|---|---|---|
| Room A1.33 | U-value | g-value | tv | te | U-value | |
| Fixed and openable | 2.77 | 0.75 | 78 | 54 | 3.07 | 3.21 |

Roller blinds (internal), semi bright, are used on all windows and external doors.

In the renovated room a flat roof window has been added.

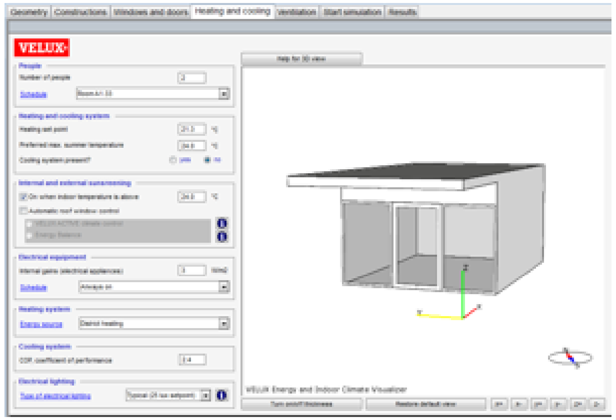
Glazing in façade windows is:
57G: Low energy, sun protection and safety features

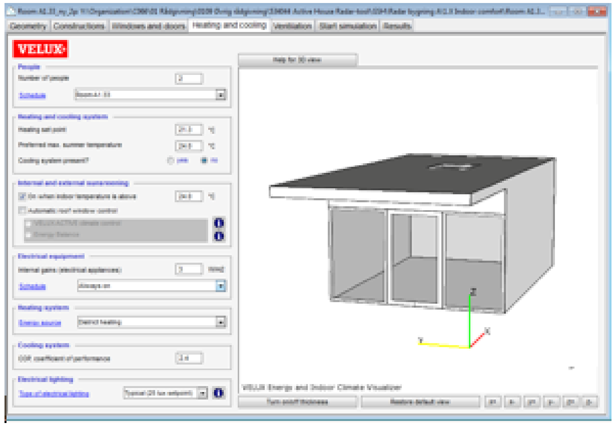
Roller blinds (internal), semi bright, are used on all windows and external doors.

Glazing in roof window is:
73U with clear cover

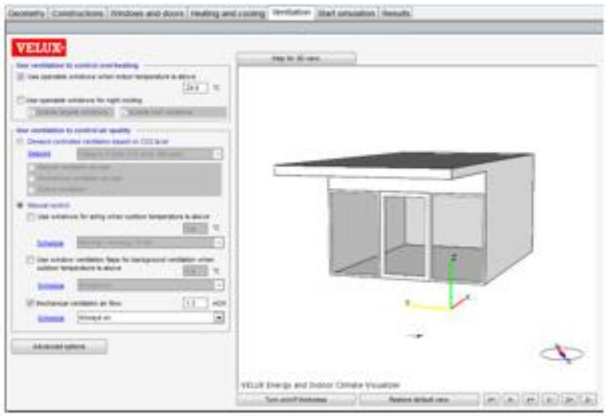
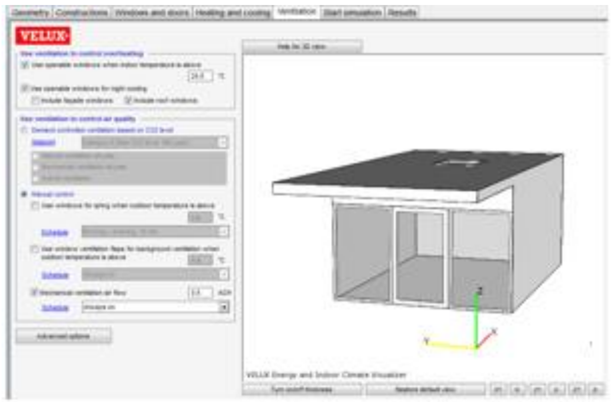
Pleated blind, dark is used on the window

## Heating and cooling





Presence in room according to schedule above.
Heating set point 21,3°C
Max temperature during summer: 24°C
Internal sun screen used when temperature above 24°C

<table>
<tr><td colspan="2">Interal gains from electrical equipment 3W/m$^2$ – always on.</td></tr>
<tr><td colspan="2">Ventilation before and after renovation</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Openable windows are used for ventilation when the temperature is above 24°C<br>No mechanical ventilation present in hotel rooms.</td><td>Openable windows are used for ventilation when the temperature is above 24°C<br>Openable windows are used for night cooling<br>Mechanical ventilation is always on – ACH 0,5</td></tr>
</table>

## AI-3 – Energy calculations

The used program is BE 10 version 7.14.5.22.
Simulations have been made based on the architectural drawings, technical drawings and information given by the project team. The calcuation is made for the hotel rooms on the 1st floor (including corridor).

This note describes the most important data used when doing the simulations.

### External walls, floors, and roofs

The calculated areas of the external walls, floors and roofs are based on the drawings. The U-values are either based on information's from the drawings or information's from Rambøll. Verification has been done according to the Danish Standard DS 418.

| | External walls, roofs and floors | Area (m²) | U (W/m²K) | b | Ht (W/K) | Dim.Inside (C) | Dim.Outside (C) | Loss (W) |
|---|---|---|---|---|---|---|---|---|
| | | 958,1 | | CtrlClick | 574,086 | | | 18640,3 |
| 1 | NE External wall (75 mm insulation cl. 50) | 40,5 | 0,6 | 1,00 | 24,3 | 20 | -12 | 777,6 |
| 2 | NW External wall (75 mm insulation cl. 50) | 57,8 | 0,6 | 1,00 | 34,68 | 20 | -12 | 1109,76 |
| 3 | SW External wall (75 mm insulation cl. 50) | 48 | 0,6 | 1,00 | 28,8 | 20 | -12 | 921,6 |
| 4 | SE Ydervæg (75 mm insulation cl. 50) | 46,8 | 0,6 | 0,70 | 19,656 | 20 | -12 | 898,56 |
| 5 | Roof (75 mm insulation cl. 50) | 765 | 0,61 | 1,00 | 466,65 | 20 | -12 | 14932,8 |
| 6 | | | | | | | | |

### Windows, skylights and doors

The properties of the windows, skylights and doors are estimated values based on the age and type of window/door/skylight.

| | Windows and outer doors | Number | Orient | Inclination | Area (m²) | U (W/m²K) | b | Ht (W/K) | Ff (-) | g (-) | Shading | Fc (-) | Dim.Inside (C) | Dim.Outside (C) | Loss (W) | Ext |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 14 | | | 177,6 | | CtrlClick | 434,797 | | | CtrlClick | | | | 14225,3 | 0/1 |
| 1 | Window 1246 x 2070 mm | 1 | NØ | 90 | 28,65 | 2,5 | 1,00 | 71,625 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 2292 | 0 |
| 2 | Window 1246 x 2070 mm | 1 | SV | 90 | 26,05 | 2,5 | 1,00 | 65,125 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 2084 | 0 |
| 3 | Window 1116 x 2070 mm | 1 | NØ | 90 | 11,71 | 2,5 | 1,00 | 29,275 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 936,8 | 0 |
| 4 | Window 1116 x 2070 mm | 1 | SV | 90 | 11,71 | 2,5 | 1,00 | 29,275 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 936,8 | 0 |
| 5 | Window 1246 x 2070 mm | 1 | NØ | 90 | 14,05 | 2,5 | 1,00 | 35,125 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 1124 | 0 |
| 6 | Window 1246 x 2070 mm | 1 | SV | 90 | 11,71 | 2,5 | 1,00 | 29,275 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 936,8 | 0 |
| 7 | Window 1250 x 1266 mm | 1 | NØ | 90 | 17,3 | 2,5 | 1,00 | 43,25 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 1384 | 0 |
| 8 | Window 1250 x 1266 mm | 1 | SV | 90 | 15,72 | 2,5 | 1,00 | 39,3 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 1257,6 | 0 |
| 9 | Window 1250 x 778 mm | 1 | NØ | 90 | 10,87 | 2,5 | 1,00 | 27,175 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 869,6 | 0 |
| 10 | Window 1250 x 778 mm | 1 | SV | 90 | 9,88 | 2,5 | 1,00 | 24,7 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 790,4 | 0 |
| 11 | Door 1005 x 2115 mm | 1 | NV | 90 | 1,96 | 1,5 | 1,00 | 2,94 | 0,47 | 0,67 | SE/NW | 1 | 20 | -12 | 94,08 | 0 |
| 12 | Skylight 1000 x 1000 mm | 1 | 0 | 0 | 5 | 3 | 1,00 | 15 | 0,8 | 0,19 | | 1 | 20 | -12 | 480 | 0 |
| 13 | Excisting glass wall 2460 x 2142 mm | 1 | SØ | 90 | 5,26 | 2,5 | 0,70 | 9,205 | 0,8 | 0,63 | SE/NW | 1 | 20 | -12 | 420,8 | 0 |
| 14 | Excisting glass wall 3600 x 2142 mm | 1 | SØ | 90 | 7,73 | 2,5 | 0,70 | 13,5275 | 0,8 | 0,63 | SE/NW | 1 | 20 | -12 | 618,4 | 0 |

## Ventilation

Data for the ventilation are based on information's from Rambøll.

| | Ventilation | Area (m²) | Fo, - | qm (l/s m²) | n vgv (-) | ti (°C) | El-HC | qn (l/s m²) | qi,n (l/s m²) | SEL (kJ/m³) | qm,s (l/s m²) | qn,s (l/s m²) | qm,n (l/s m²) | qn,n (l/s m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zone | 770 | | Winter | | | 0/1 | Winter | Winter | | Summer | Summer | Night | Night |
| 1 | Building H | 770 | 1 | 0 | 0 | 0 | 0 | 0,3 | 0 | 0 | 0 | 0,9 | 0 | 0 |

## Internal loads

Data for the internal loads are based on information's from Rambøll.

| | Internal heat supply | Area (m²) | Persons (W/m²) | App. (W/m²) | App,night (W/m²) |
|---|---|---|---|---|---|
| | Zone | 770,0 | 1155,0 W | 2695,0 W | 0,0 W |
| +1 | People | 770 | 1,5 | 3,5 | 0 |

## Heat distribution

The heat distribution system is mainly based on radiators with a hot water temperature of 45deg C at DUT. The heating is generated in an exchanger. Data for the exchanger are based on information's from Rambøll.

Description: District Heating Exchanger

District heating exchanger

| | |
|---|---|
| 290 | Nominal effect, kW |
| 2 | Heat loss from exchanger, W/K |
| ☐ | DHW heating through exchanger |
| 45 | Exchanger temperature, minimum, °C |
| 0 | Temp.factor, b for setup room (Heated zone: b = 0, Outdoors: b = 1) |
| 5 | Automatics, stand-by, W |

## DHW

The DHW system has been entered according to informations from Rambøll.

Hot-water tank

Description: DHW

| | |
|---|---|
| 1 | Number of tanks; 1 Part of hot-water consumption, - |
| 2000 | Tank volume, litre (For solar heating containers, state total volume) |
| 60 | Supply temperature from central heating, °C |
| Nej | El. heating of DHW (If 'No' the boiler operates in summer) |
| ☐ | Solar heat tank with back-up power (Correction for temp.layering) |
| 5 | Heat loss from hot-water tank, W/K |
| 0 | Temp. factor, b for setup room, - (Heated zone: b = 0, Outdoor: b = 1) |

Charging pump

| | Effect, W | | Charge effect, kW |
|---|---|---|---|
| For combi-pump, state effect as 0 W | 0 | ☐ Controlled | 0 |

**AI-4 – Environment**
See the section AII -4

## Annex II: Comments to AH radar – Building A after renovation

### AII-1 – Daylight

Daylight simulations was made by VELUX.

### AII-2 – Indoor Climate

See comments in AI-2 above.

### AII-3 – Energy calculations

Energy calculations from Be10
The program used is BE 10 version 6, 11, 10, 19.
Simulations was made based on the architectural drawings, technical drawings and information given by the project team. This note describes the most important data used when doing the simulations.

External walls, floors, and roofs
The calculated areas of the external walls, floors and roofs are based on the drawings. The U-values are either based on information's from the drawings or information's from Rambøll. Verification has been done according to the Danish Standard DS 418.

| | External walls, roofs and floors | Area (m²) | U (W/m²K) | b | Ht (W/K) | Dim.Inside (C) | Dim.Outside (C) | Loss (W) |
|---|---|---|---|---|---|---|---|---|
| | | 951,1 | | CtrlClick | 152,71 | | | 4947,38 |
| 1 | NE External wall (75 mm insulation cl. 50 + 100 mm iinsulation | 40,5 | 0,217 | 1,00 | 8,7885 | 20 | -12 | 281,232 |
| 2 | NW External wall (75 mm insulation cl. 50 + 195 mm insulation c | 57,8 | 0,135 | 1,00 | 7,803 | 20 | -12 | 249,696 |
| 3 | SW External wall (75 mm insulation cl. 50 + 100 mm insulation c | 48 | 0,217 | 1,00 | 10,416 | 20 | -12 | 333,312 |
| 4 | SE Ydervæg (75 mm insulation cl. 50 + 195 mm insulation cl. 34) | 46,8 | 0,135 | 0,70 | 4,4226 | 20 | -12 | 202,176 |
| +5 | Roof (75 mm insulation cl. 50 + 150 mm insulation cl. 34) | 758 | 0,16 | 1,00 | 121,28 | 20 | -12 | 3880,96 |

Windows and door
The properties of the windows and doors are from Velfac's product sheets, while the orientation and shading of the windows and doors are based on the drawings. The properties of the skylights are from Velux's product sheets.

| | Windows and outer doors | Number | Orient | Inclination | Area (m²) | U (W/m²K) | b | Ht (W/K) | Ff (-) | g (-) | Shading | Fc (-) | Dim.Inside (C) | Dim.Outside (C) | Loss (W) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | | | 185,16 | | CtrlClick | 231,466 | | | CtrlClick | | | | 7605,84 |
| +1 | VELFAC window GPV-13 | 1 | NØ | 90 | 28,65 | 1,4 | 1,00 | 40,11 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 1283,52 |
| 2 | VELFAC window GPV-13 | 1 | SV | 90 | 26,05 | 1,4 | 1,00 | 36,47 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 1167,04 |
| 3 | VELFAC window GPD-4 | 1 | NØ | 90 | 11,71 | 1,4 | 1,00 | 16,394 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 524,608 |
| 4 | VELFAC window GPD-4 | 1 | SV | 90 | 11,71 | 1,4 | 1,00 | 16,394 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 524,608 |
| 5 | VELFAC window GPD-5 | 1 | NØ | 90 | 14,05 | 1,4 | 1,00 | 19,67 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 629,44 |
| 6 | VELFAC window GPD-5 | 1 | SV | 90 | 11,71 | 1,4 | 1,00 | 16,394 | 0,85 | 0,6 | SW/NE | -0,8 | 20 | -12 | 524,608 |
| 7 | VELFAC window GPV-14 | 1 | NØ | 90 | 17,3 | 1,08 | 1,00 | 18,684 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 597,888 |
| 8 | VELFAC window GPV-14 | 1 | SV | 90 | 15,72 | 1,08 | 1,00 | 16,9776 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 543,283 |
| 9 | VELFAC window GPFR-1 | 1 | NØ | 90 | 10,87 | 1,08 | 1,00 | 11,7396 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 375,667 |
| 10 | VELFAC window GPFR-1 | 1 | SV | 90 | 9,88 | 1,08 | 1,00 | 10,6704 | 0,51 | 0,62 | SW/NE | -0,8 | 20 | -12 | 341,453 |
| 11 | VELFAC door | 1 | NV | 90 | 1,96 | 1,5 | 1,00 | 2,94 | 0,47 | 0,67 | SE/NW | 1 | 20 | -12 | 94,08 |
| 12 | VELUX skylight CVP 600 x 600 mm | 1 | 0 | 0 | 7,56 | 0,73 | 1,00 | 5,5188 | 0,8 | 0,2 | | 1 | 20 | -12 | 176,602 |
| 13 | VELUX skylight CSP 1000 x 1000 mm | 1 | 0 | 0 | 5 | 1 | 1,00 | 5 | 0,8 | 0,19 | | 1 | 20 | -12 | 160 |
| 14 | Excisting glass wall incl. new VELFAC door YD-11 | 1 | SØ | 90 | 5,26 | 1 | 0,70 | 3,682 | 0,8 | 0,63 | SE/NW | 1 | 20 | -12 | 168,32 |
| 15 | Excisting glass wall | 1 | SØ | 90 | 7,73 | 2 | 0,70 | 10,822 | 0,8 | 0,63 | SE/NW | 1 | 20 | -12 | 494,72 |

## Ventilation

Data for the ventilation are based on information's from Rambøll.

| | Ventilation | Area (m²) | Fo, - | qm (l/s m²) | n vgv (-) | ti (°C) | El-HC | qn (l/s m²) | qi,n (l/s m²) | SEL (kJ/m³) | qm,s (l/s m²) | qn,s (l/s m²) | qm,n (l/s m²) | qn,n (l/s m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zone | 770 | | Winter | | | 0/1 | Winter | Winter | | Summer | Summer | Night | Night |
| 1 | Building H | 770 | 1 | 0,41 | 0,75 | 18 | 0 | 0,13 | 0 | 1 | 0,41 | 0,9 | 0 | 0 |

## Internal loads

Data for the internal loads are based on information's from Rambøll.

| | Internal heat supply | Area (m²) | Persons (W/m²) | App. (W/m²) | App,night (W/m²) |
|---|---|---|---|---|---|
| | Zone | 770,0 | 1155,0 W | 2695,0 W | 0,0 W |
| +1 | People | 770 | 1,5 | 3,5 | 0 |

## Heat distribution

The heat distribution system is mainly based on radiators with a hot water temperature of 45deg C at DUT. The heating is generated in a heat exchanger. Data for the exchanger are based on information from Rambøll.

Description: District Heating Exchanger

District heating exchanger

- 290 Nominal effect, kW
- 2 Heat loss from exchanger, W/K
- [ ] DHW heating through exchanger
- 45 Exchanger temperature, minimum, °C
- 0 Temp.factor, b for setup room (Heated zone: b = 0, Outdoors: b = 1)
- 5 Automatics, stand-by, W

## DHW

The DHW system has been entered according to informations from Rambøll.

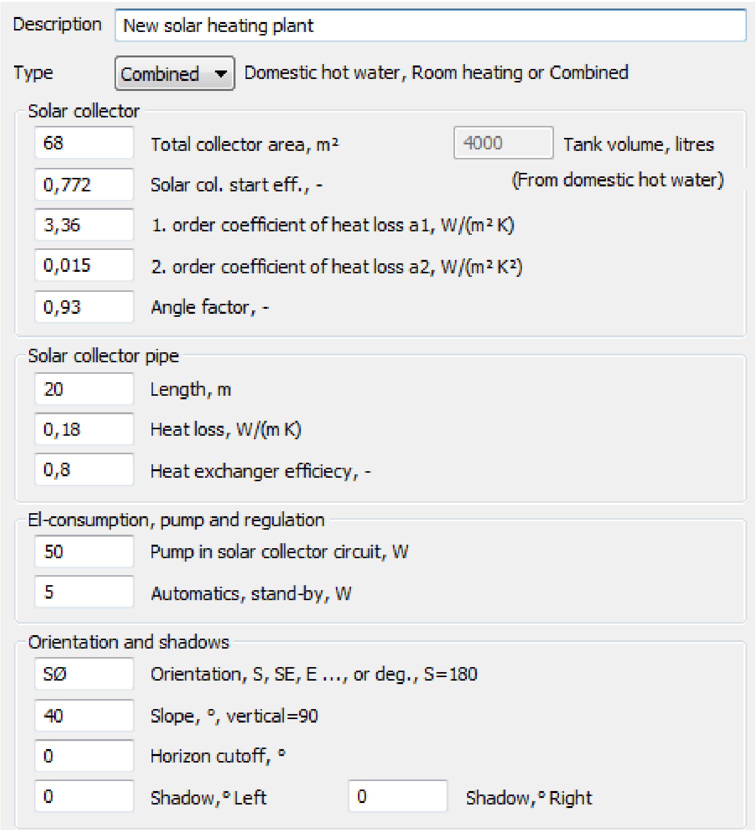
Hot-water tank

Description: DHW

- 1 Number of tanks — 1 Part of hot-water consumption, -
- 4000 Tank volume, litre (For solar heating containers, state total volume)
- 45 Supply temperature from central heating, °C
- Nej El. heating of DHW (If 'No' the boiler operates in summer)
- [x] Solar heat tank with back-up power (Correction for temp.layering)
- 5 Heat loss from hot-water tank, W/K
- 0 Temp. factor, b for setup room, - (Heated zone: b = 0, Outdoor: b = 1)

## Solar heating

The solar heating system has been entered according to Batec's product sheets and informations from Rambøll.



| | |
|---|---|
| Description | New solar heating plant |
| Type (Domestic hot water, Room heating or Combined) | Combined |
| **Solar collector** | |
| Total collector area, m² | 68 |
| Tank volume, litres (From domestic hot water) | 4000 |
| Solar col. start eff., - | 0,772 |
| 1. order coefficient of heat loss a1, W/(m² K) | 3,36 |
| 2. order coefficient of heat loss a2, W/(m² K²) | 0,015 |
| Angle factor, - | 0,93 |
| **Solar collector pipe** | |
| Length, m | 20 |
| Heat loss, W/(m K) | 0,18 |
| Heat exchanger efficiecy, - | 0,8 |
| **El-consumption, pump and regulation** | |
| Pump in solar collector circuit, W | 50 |
| Automatics, stand-by, W | 5 |
| **Orientation and shadows** | |
| Orientation, S, SE, E ..., or deg., S=180 | SØ |
| Slope, °, vertical=90 | 40 |
| Horizon cutoff, ° | 0 |
| Shadow,° Left | 0 |
| Shadow,° Right | 0 |

## AII-4 – Environment

The used program is AH LCA evaluation tool - Version 1.2 (Excel-based calculation).
The evaluation was made on Building A as indicated in figure 1 below.

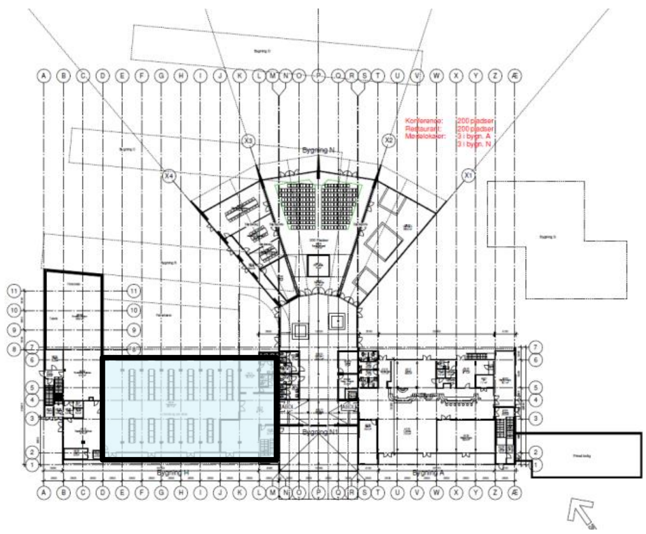


*Figure 5: Indication of area included in LCA calculation*

This note describes important assumptions made when doing the calculation. The drawings from ByggeWeb was used to define the materials of the different construction elements.

The building has been evaluated both before and after renovation.

770 m² building is included in the LCA. The estimated lifetime of the building is 50 years. The LCA calcuation is made for the main construction elements and for the hotel rooms on the 1st floor (including corridor). Energy data for the calculation are from BE10 calcuations.

| Ref in LCA tool | Issue |
|---|---|
| 11. Outside walls | Outside walls are divided into four wall types: northeast/southwest (NE/NW), southeast/northwest (SE/NW), stern and glass railing |
| 12. Inner walls | There is no renovation plan for the inner walls. The inner walls are therefore not included in the LCA-calculation. |
| 13. Windows | Windows and doors are grouped according to type |
| 14. Slabs | There is no renovation plan for the slabs in building H. Slabs are therefore not included in the LCA-calculation. |
| 15. Roofs | Roofs are divided into two groups: Roof (the general roof construction) and Roof balcony (the roof over the balcony) |
| 16. Foundation | There is no renovation plan for the foundation in building H. Foundation is therefore not included in the LCA-calculation. |
| 17. Technical installations | Technical installations include 68 m² solar panels and a new solar hot water storage tank (2000 L). |
| | |
| 3.3.1 Sustaina-ble construc-tion – Recycla-ble content | The score is based on estimations and basic knowledge of the materials.<br>The recyclable content score only includes the main construction elements of the building. |
| 3.3.2 Sustainable construction - Responsible sourcing | The score is based on estimations and information from the manufacturer’s homepage. |

## Annex III: Comments to AH radar - Building N

### AIII-1 – Daylight

Daylight calculations have been performed by VELUX A/S

### AIII-2 – Indoor Climate

Comments to Indoor Climate simulations:

The indoor climate was simulated using the program IES VE. The simulations was done by Christoffer Borgwardt-Stampe from Rambøll, February 2014.
Indoor climate was evaluated in the conference room as indicated in figure 1 below.

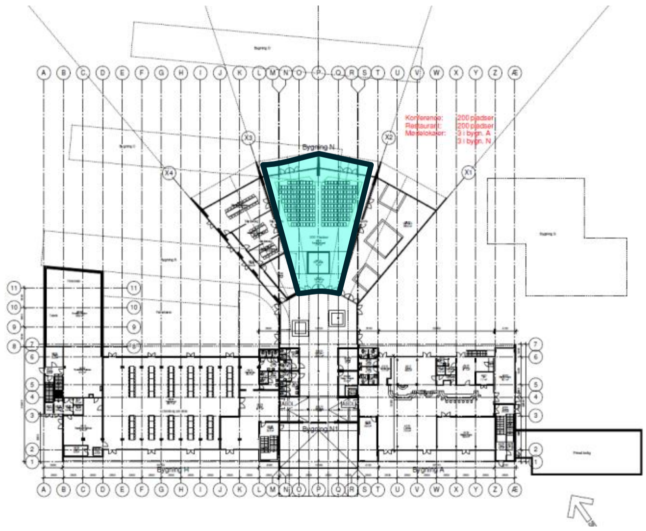


Figure 6: Indication of area included in indoor climate simulations

For the simulations an occupancy of 200 people was assumed.
The weather data used for the simulations was DRY 2013.

Results of the simulations was sent to Technological Institute, Sustainable Construction February 7th 2014. The results was used in the Active House evaluation of Building N represented by the conference area. The

## AIII-3 – Energy calculations

The energy calculations was performed by Rambøll. Results used for the Active House evaluation is shown below

Nøgletal, kWh/m² år

Energiramme BR 2010

| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
|---|---|---|
| 73,8 | 0,0 | 73,8 |
| Samlet energibehov | | 47,1 |

Energiramme Lavenergibyggeri 2015

| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
|---|---|---|
| 42,5 | 0,0 | 42,5 |
| Samlet energibehov | | 36,6 |

Energiramme Byggeri 2020

| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
|---|---|---|
| 25,0 | 0,0 | 25,0 |
| Samlet energibehov | | 28,2 |

| Bidrag til energibehovet | |
|---|---|
| Varme | 52,7 |
| El til bygningsdrift | 12,6 |
| Overtemp. i rum | 1,9 |

| Netto behov | |
|---|---|
| Rumopvarmning | 45,4 |
| Varmt brugsvand | 6,9 |
| Køling | 12,9 |

| Udvalgte elbehov | |
|---|---|
| Belysning | 4,0 |
| Opvarmning af rum | 0,0 |
| Opvarmning af vbv | 0,0 |
| Varmepumpe | 0,0 |
| Ventilatorer | 4,0 |
| Pumper | 0,7 |
| Køling | 3,9 |
| Totalt elforbrug | 26,7 |

| Varmetab fra installationer | |
|---|---|
| Rumopvarmning | 0,2 |
| Varmt brugsvand | 1,7 |

| Ydelse fra særlige kilder | |
|---|---|
| Solvarme | 0,0 |
| Varmepumpe | 0,0 |
| Solceller | 15,6 |
| Vindmøller | 0,0 |

Building N is supposed to fulfil the criteria of LEK 2015. As shown above the criteria is fulfilled. To meet the requirements of input for the Active House evaluation, the percentage of renewable energy in the energy supply must be entered. Concerning the heat supply the entered values comes from data provided by "Rønne fjernvarme". Concerning the electricity, the values are based on the national average from Denmark.

**AIII-4 – Enviroment**

Comments to LCA calculation, - GSH Building N:
The used program is AH LCA evaluation tool - Version 1.2 (Excel-based calculation).
The evaluation was made on Building N as indicated in figure 1 below.

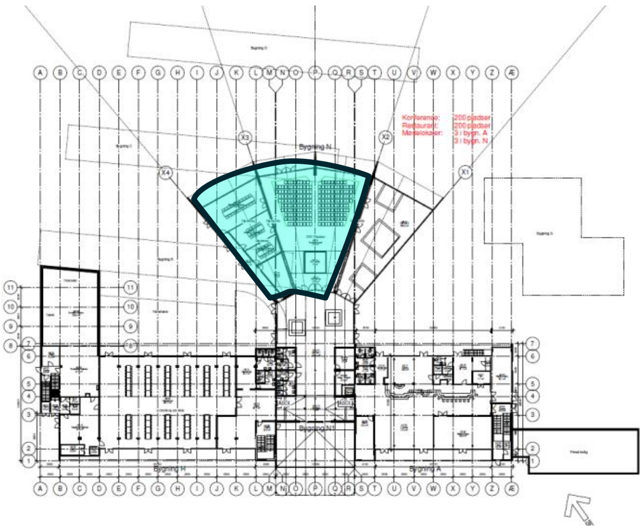


Figure 7: Indication of area included in LCA calculation

This note describes important assumptions made when doing the calculation. The drawings from ByggeWeb was used to define the materials of the different construction elements.

660m$^2$ building is included in the LCA. The estimated lifetime of the building is 50 years. The LCA calcuations is made for the main construction elements only. Technical installations are not included in the calculation. These usually account for 20% of the overall environmental load. Due to that the result has been increase by 20%.
Energy data for the calculation are from BE10 calcuations done by Rambøll.

| **Ref in LCA tool** | **Issue** |
|---|---|
| **11. Outside walls** | Outside walls are divided into heavy and light walls |
| **12. Inner walls** | Only heavy inner walls are included in the LCA.<br>Sliding doors are included in the LCA as inner walls. |
| **13. Windows** | Windows are grouped based on area; 1,82m$^2$ window is used to calculate all windows in the building. |
| **17. Technical installations** | Technical installations was not calculated specifically in the LCA. To take technical installations into account 20% was added to the overall result. |
| | |
| **3.3.1 Sustainable construction –** | The score is based on best guess in cooperation with Lasse Lind, GXN.<br>The judgement is only made for the elements of the main construction and the current knowledge in terms of recycling potential of these. |

| | |
|---|---|
| **Recyclable content** | |
| **3.3.2 Sustainable construction - Responsible sourcing** | The score is based on best guess in cooperation with Lasse Lind, GXN. |