Transsolar
KlimaEngineering

Living Places – Germany

Hygge house evaluated within the German framework

NA, IT, KH, PV, SdV, FG, LO

Stuttgart

16.04.2026

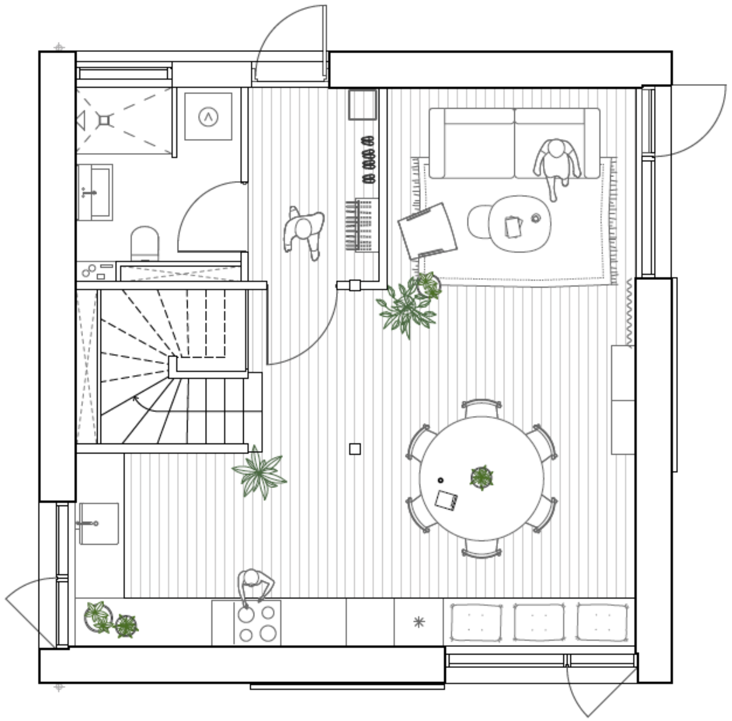
Introduction

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

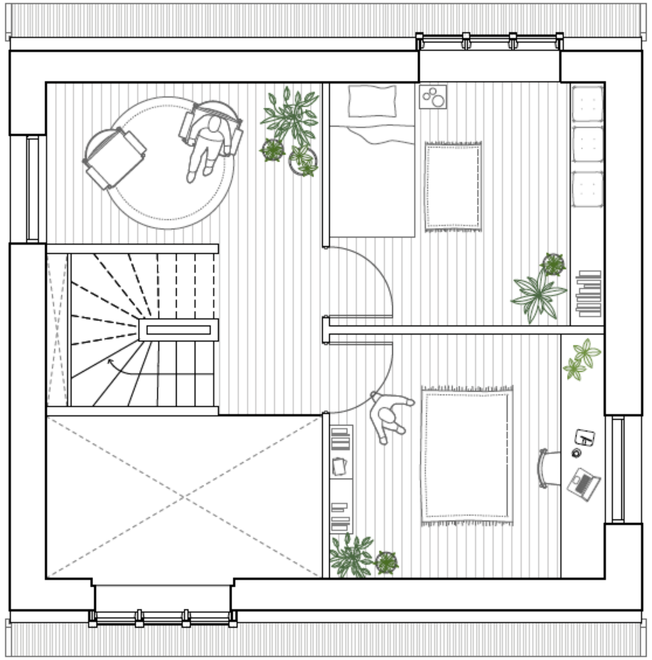
Hygge House

Hygge House
Description

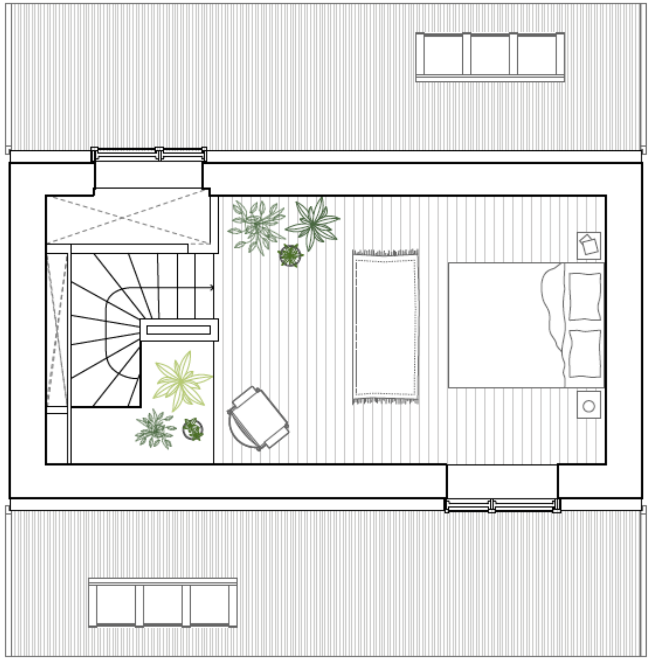
House floor plans



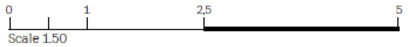
GROUND FLOOR



FIRST FLOOR



SECOND FLOOR



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Comfort

Daylight

Summary of the results according EN 17037

HYGGE HOUSE

	Occupied space reaching the target daylight factor $D_T \geq 2.2\%$
Ground floor	91%
First floor	39%
Second floor	100%

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort

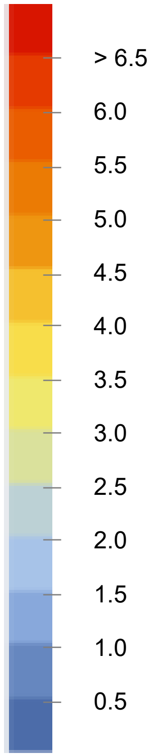
Daylight

Daylight factor (DF [%])

Daylight access can be assessed by daylight factor calculation. The daylight factor is the **ratio** of the **internal horizontal illuminance** (Ep in lux) compared to the **external horizontal illuminance** (Ea in lux) under an **overcast sky** (CIE Overcast) expressed in percent. The calculation is used as a measure of the daylighting of rooms in buildings under overcast conditions. The effect of direct sunlight is not shown. The daylight factor is **independent of the direction of the sky**, **as well as of the date and time**. Influences of glazing and pollution are included.

Daylight

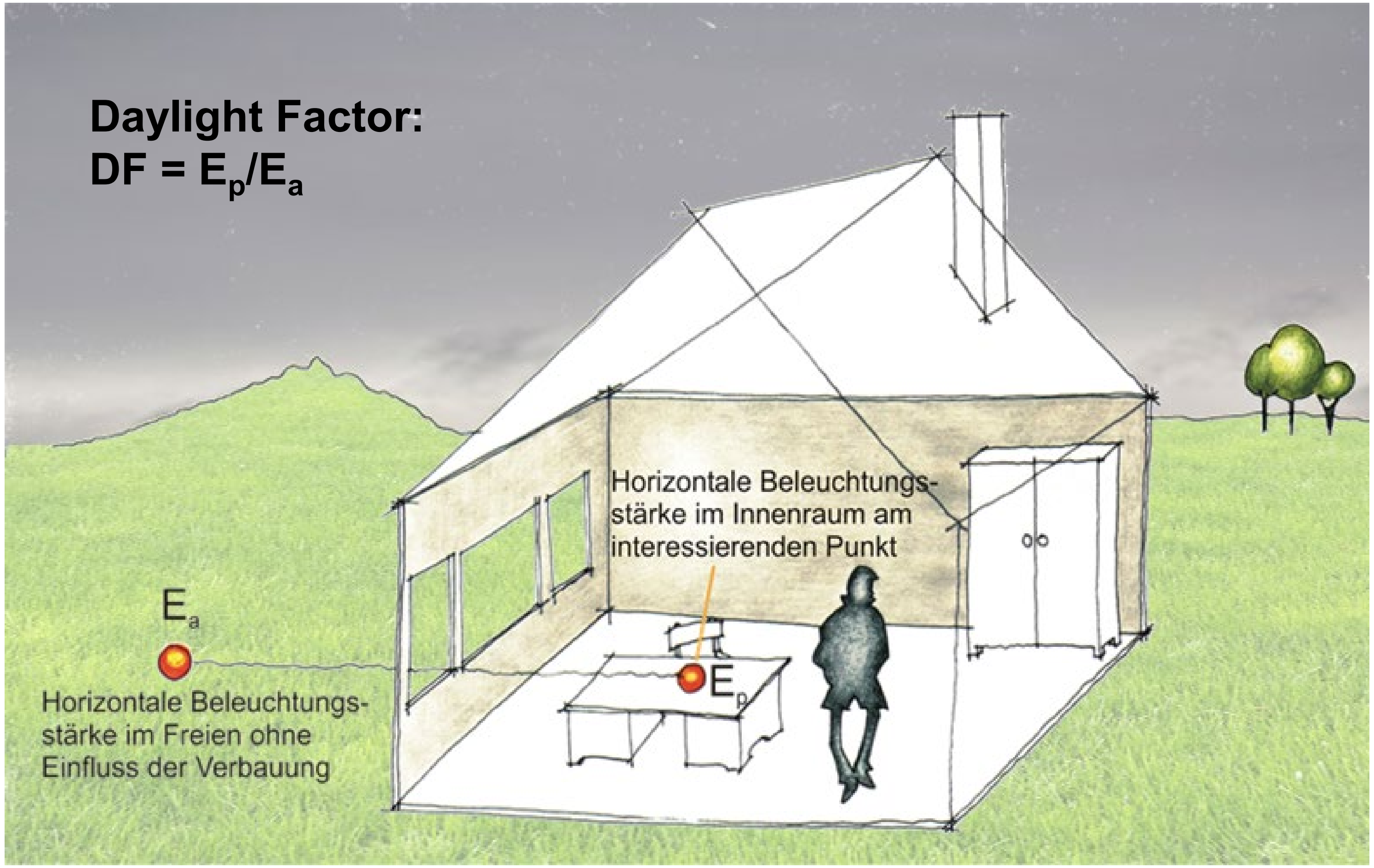
Factor DF [%]



Higher than 6%
Electric lighting is rarely needed during the day, but there is a risk of overheating

Between 2% and 5%
Good daylight illumination, little to no artificial lighting needed during the day. Good balance between daylight and thermal comfort.

Smaller than 2%
Low daylight illumination, high demand for artificial light



Active House | Comfort

Daylight

Active House – Daylight criteria, option 1: Daylight factor method according EN 17037

The EN 17037 (European Standard) considers measured median external illuminance levels for the capital cities of European countries in function of their latitude. For Berlin in Germany, the median external diffuse illuminance value is 13 900 lx – being 3 900 lx more than the standardized 10 000 lx that are usually assumed for the calculation of the daylight factor.

This means lower DF values are required to achieve the same illuminance levels (i.e. the illuminance target of 300 lx is already achieved with a daylight factor of 2.2%).

Table A.3 — Values of *D* for daylight openings to exceed an illuminance level of 100, 300, 500 or 750 lx for a fraction of daylight hours $F_{time,\%}$ = 50 % for 33 capitals of CEN national members

Nation	Capital [a]	Geographical latitude φ [°]	Median External Diffuse Illuminance $E_{v,d,med}$	*D* to exceed 100 lx	*D* to exceed 300 lx	*D* to exceed 500 lx	*D* to exceed 750 lx
Poland	Warsaw	52,17	14 700	0,7 %	2,0 %	3,4 %	5,1 %
The Netherlands	Amsterdam	52,30	14 400	0,7 %	2,1 %	3,5 %	5,2 %
Germany	Berlin	52,47	13 900	0,7 %	2,2 %	3,6 %	5,4 %
Ireland	Dublin	53,43	14 900	0,7 %	2,0 %	3,4 %	5,0 %

➔ Target: daylight factor ≥ 2.2%

Accordingly, the results were filtered in order to display equivalent illuminance levels (in lx) using a user-defined legend.

Daylight Factor DF [%]
EN 17037

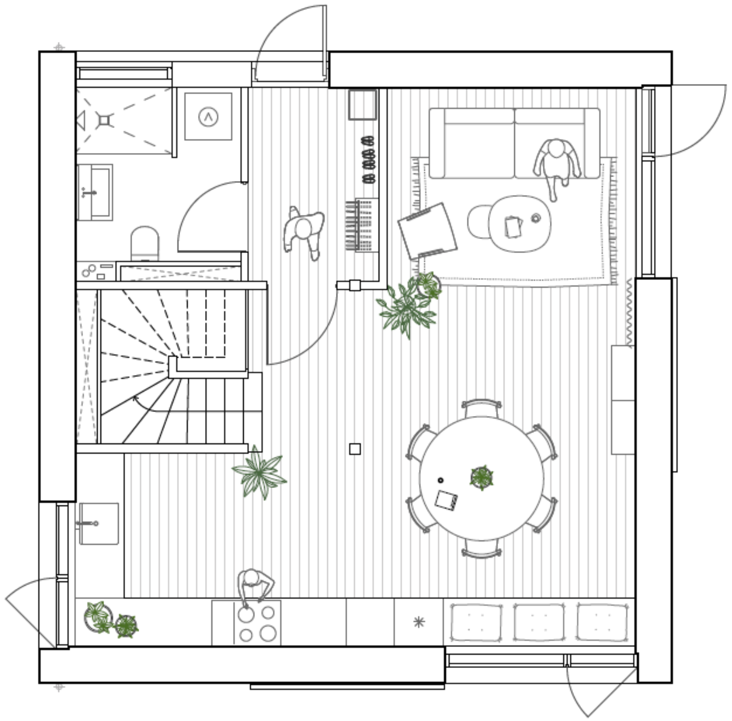
100 lx | 300 lx | 500 lx

0.7 | 2.2 | 3.6

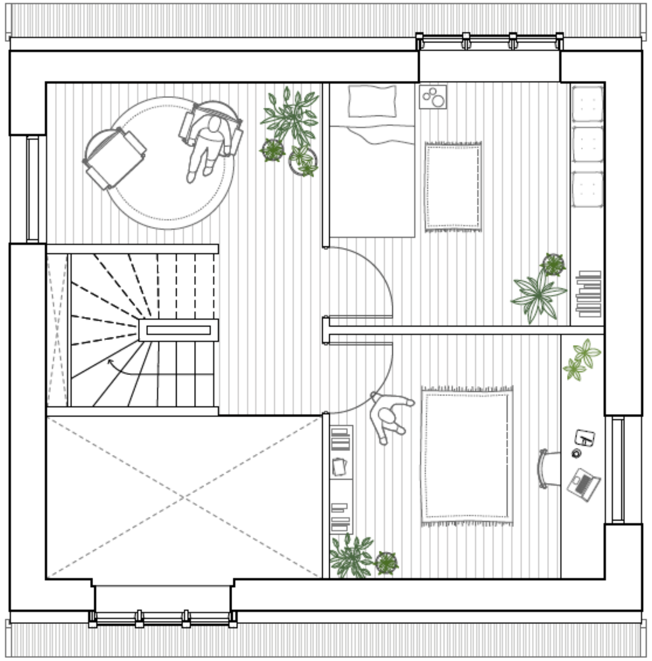
Active House | Comfort

Daylight

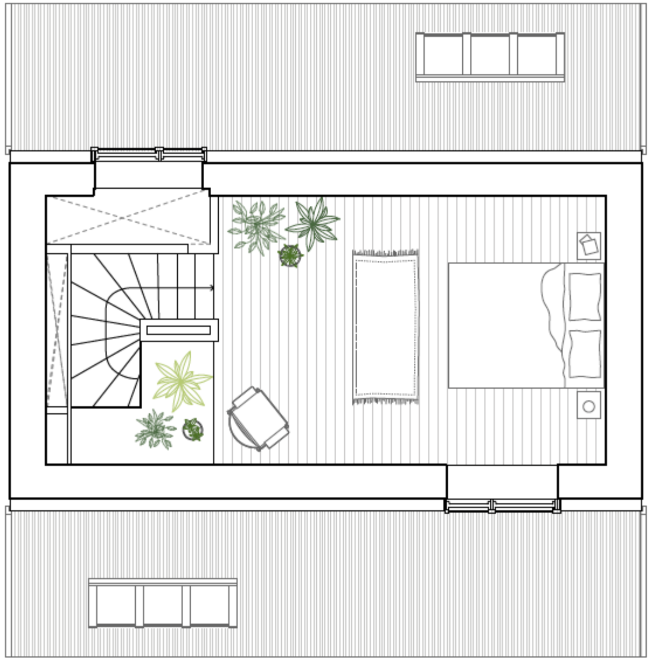
Boundary conditions: house plans



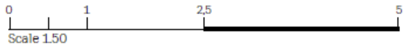
GROUND FLOOR



FIRST FLOOR



SECOND FLOOR



Active House | Comfort

Daylight

Boundary conditions

Roof windows

Glass

Transmission 62%

Frame

Reflectance 80%

Flat-roof window

Glass

Transmission 70%

Frame

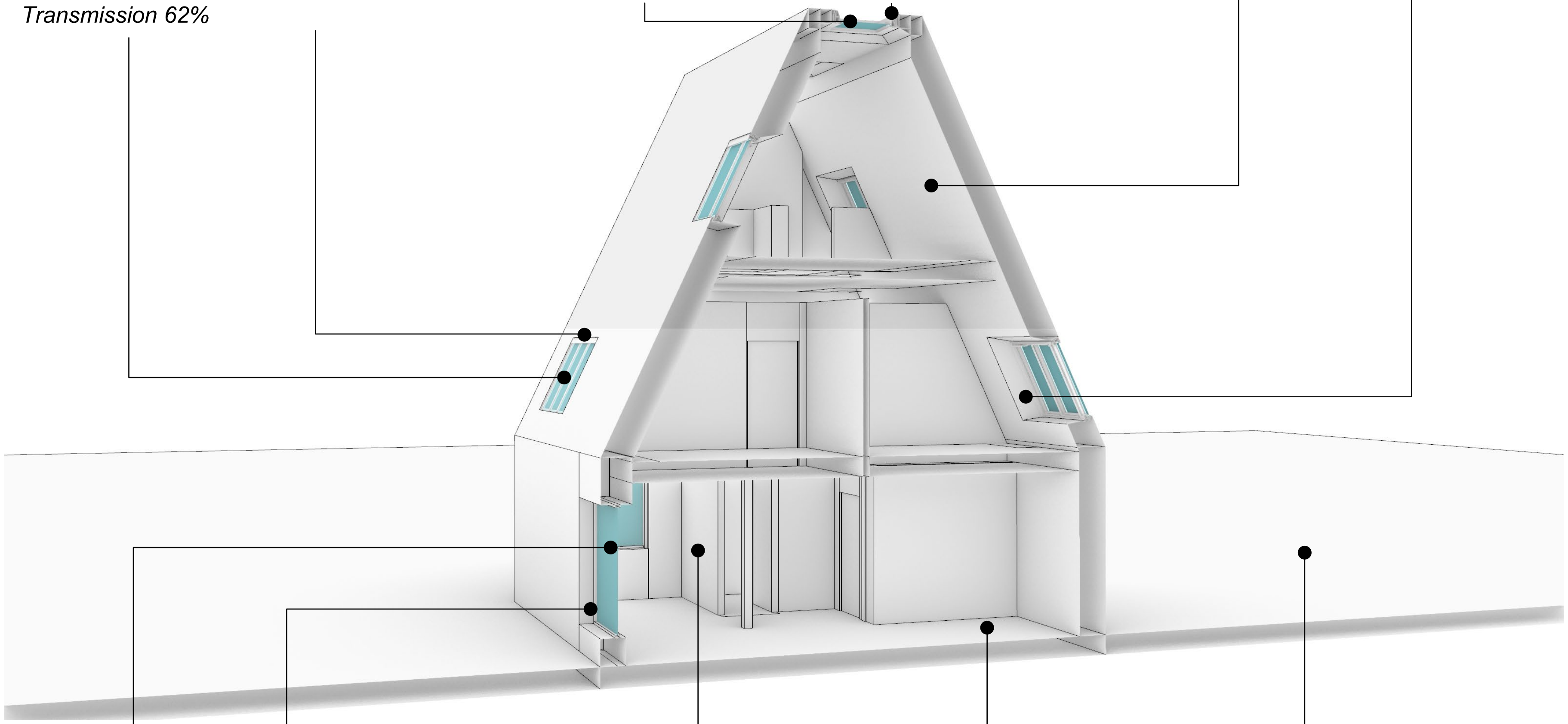
Reflectance 80%

Ceiling

Reflectance 80%

Window lining

Reflectance 80%



Vertical windows

Glass

Transmission 70%

Frame

Reflectance 80%

Interior walls

Reflectance 50%

Interior floor

Reflectance 30%

Ground floor

Reflectance 20%

Analysis grid: 0.1 m x 0.1 m

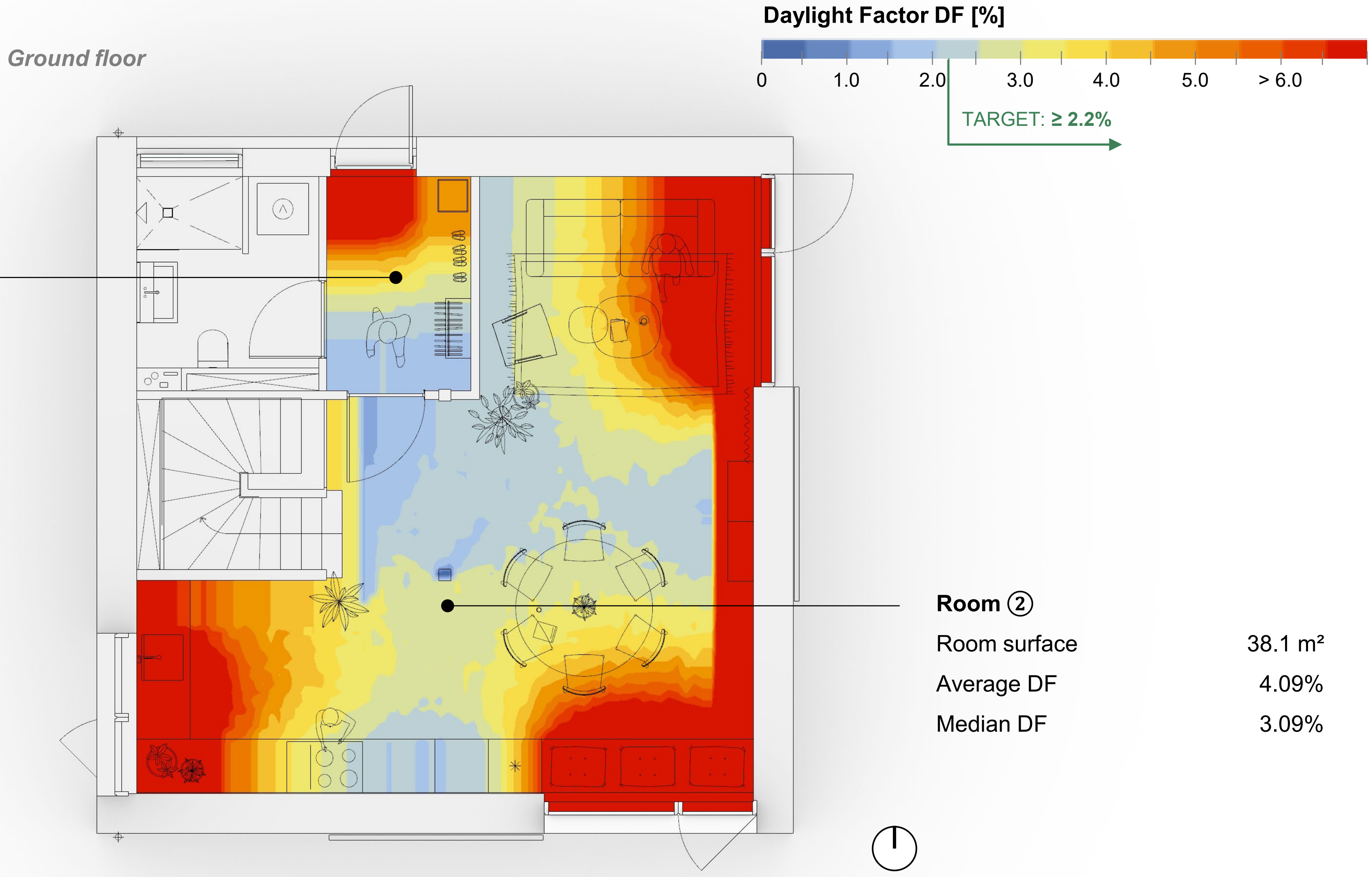
Level offset: 0.85 m

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort

Daylight

Results – Daylight factor



Room ①

Room surface	4.4 m²
Average DF	3.87%
Median DF	3.44%

Room ②

Room surface	38.1 m²
Average DF	4.09%
Median DF	3.09%

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

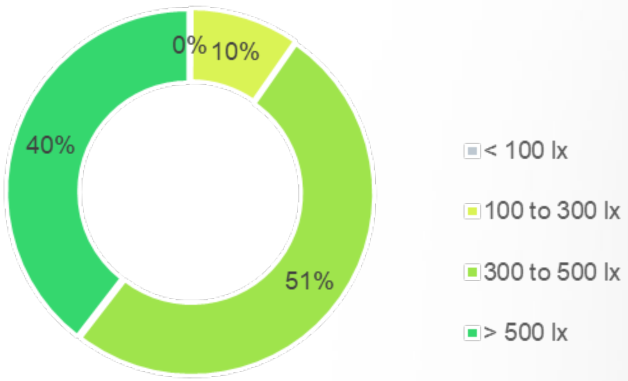
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort
Daylight

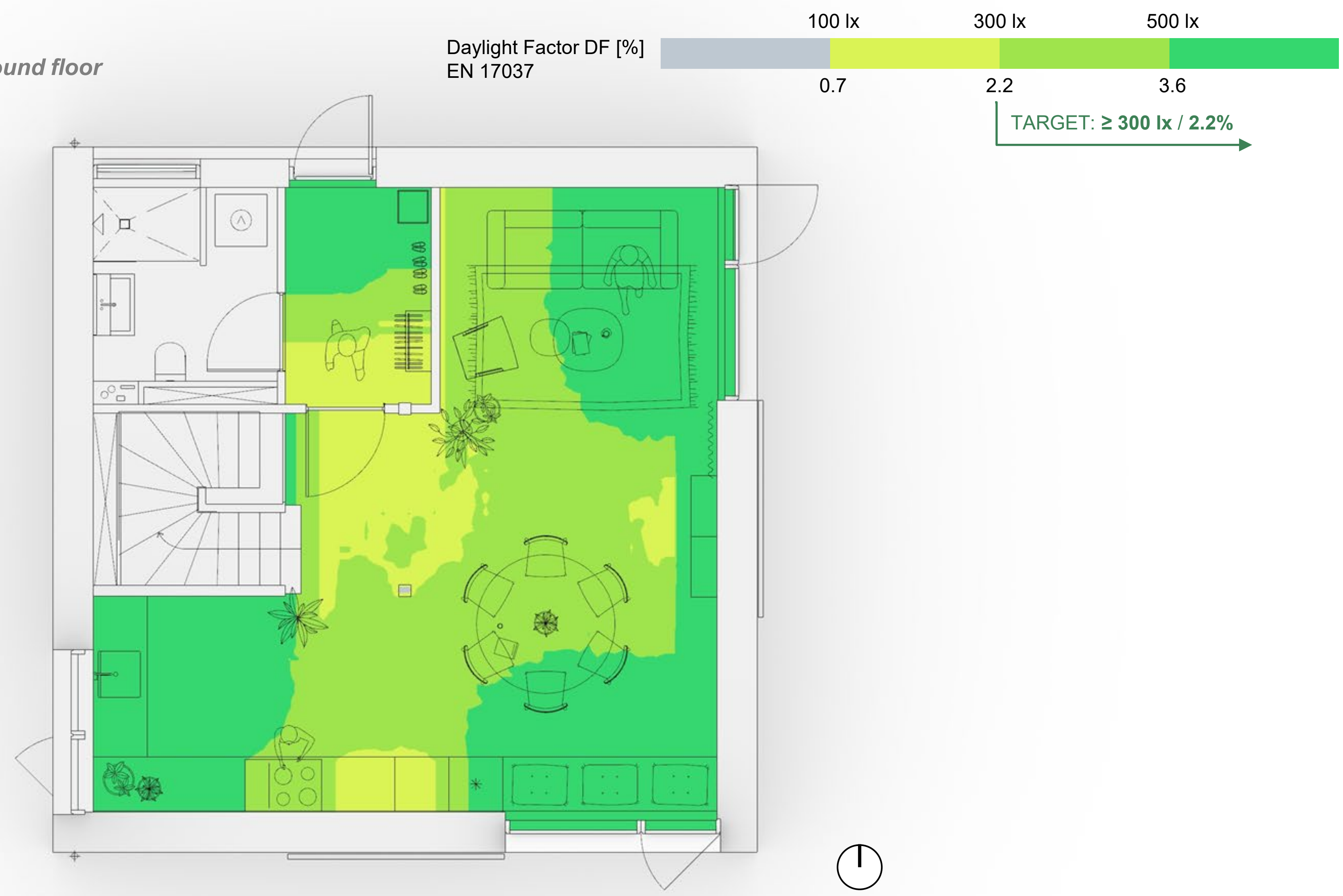
Results according EN 17037

Overall area percentage



➔ Target daylight factor $D_T \geq 2.2\%$ is reached for **91% of the occupied space** analyzed.

Ground floor



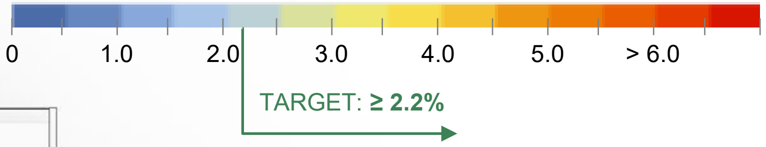
Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort

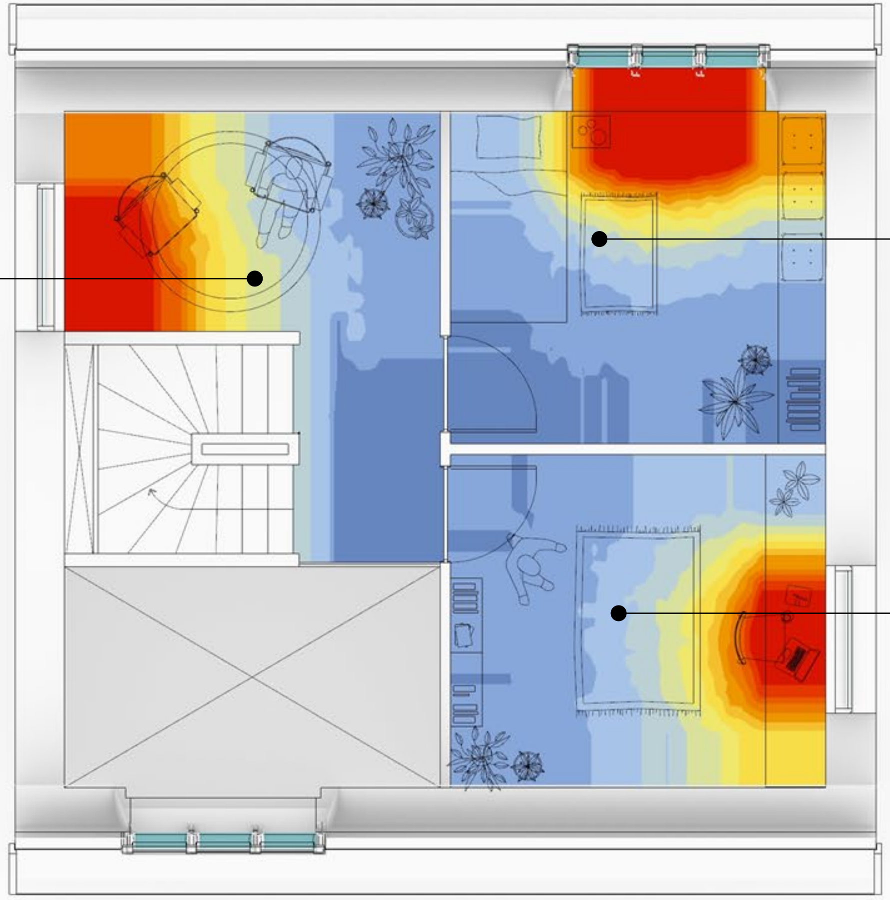
Daylight

Results – Daylight factor

Daylight Factor DF [%]



First floor



Room ③

Room surface	10.5 m²
Average DF	2.65%
Median DF	1.94%

Room ④

Room surface	11.9 m²
Average DF	2.83%
Median DF	1.63%

Room ⑤

Room surface	11.2 m²
Average DF	2.35%
Median DF	1.87%

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

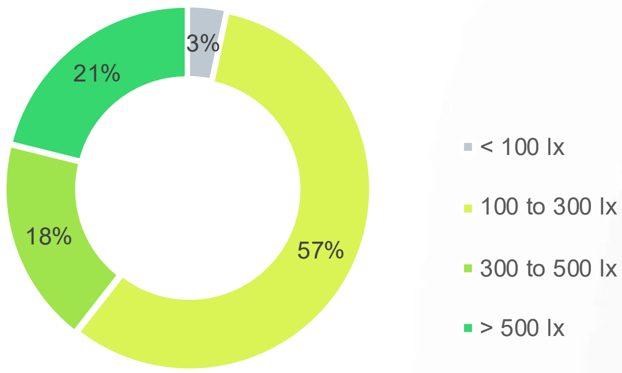
Active House | Comfort

Daylight

HYGGE HOUSE

Results according EN 17037

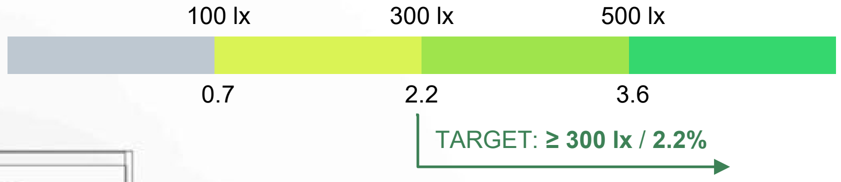
Overall area percentage



➔ Target daylight factor $D_T \geq 2.2\%$ is reached for **39% of the occupied space** analyzed.

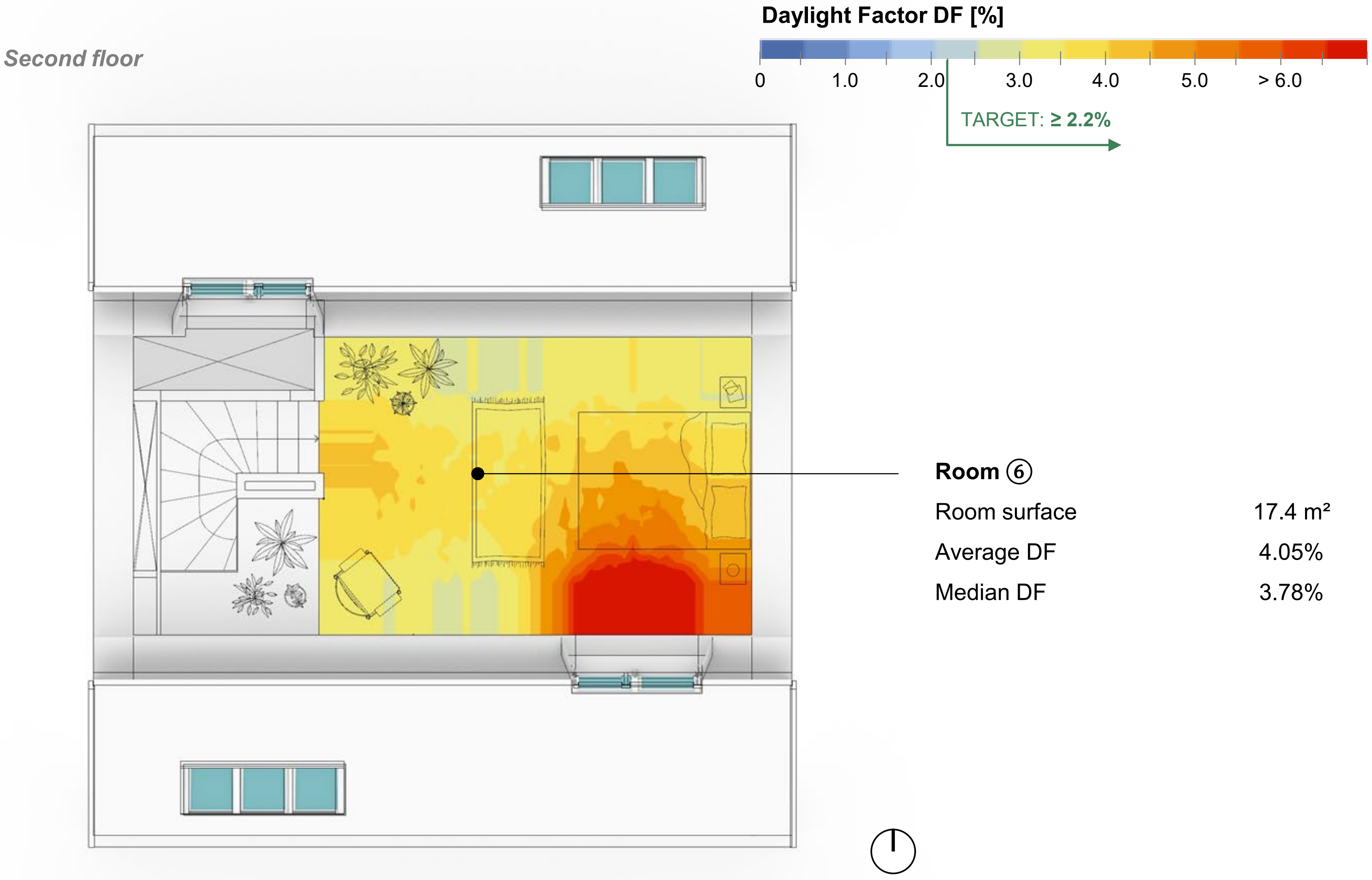
First floor

Daylight Factor DF [%]
EN 17037



Active House | Comfort
Daylight

Results – Daylight factor



Room 6

Room surface	17.4 m²
Average DF	4.05%
Median DF	3.78%

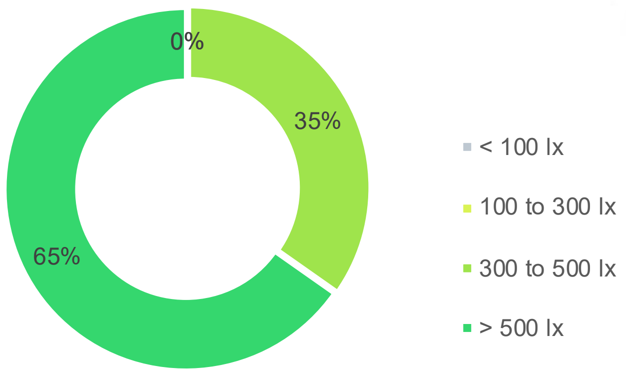
Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort

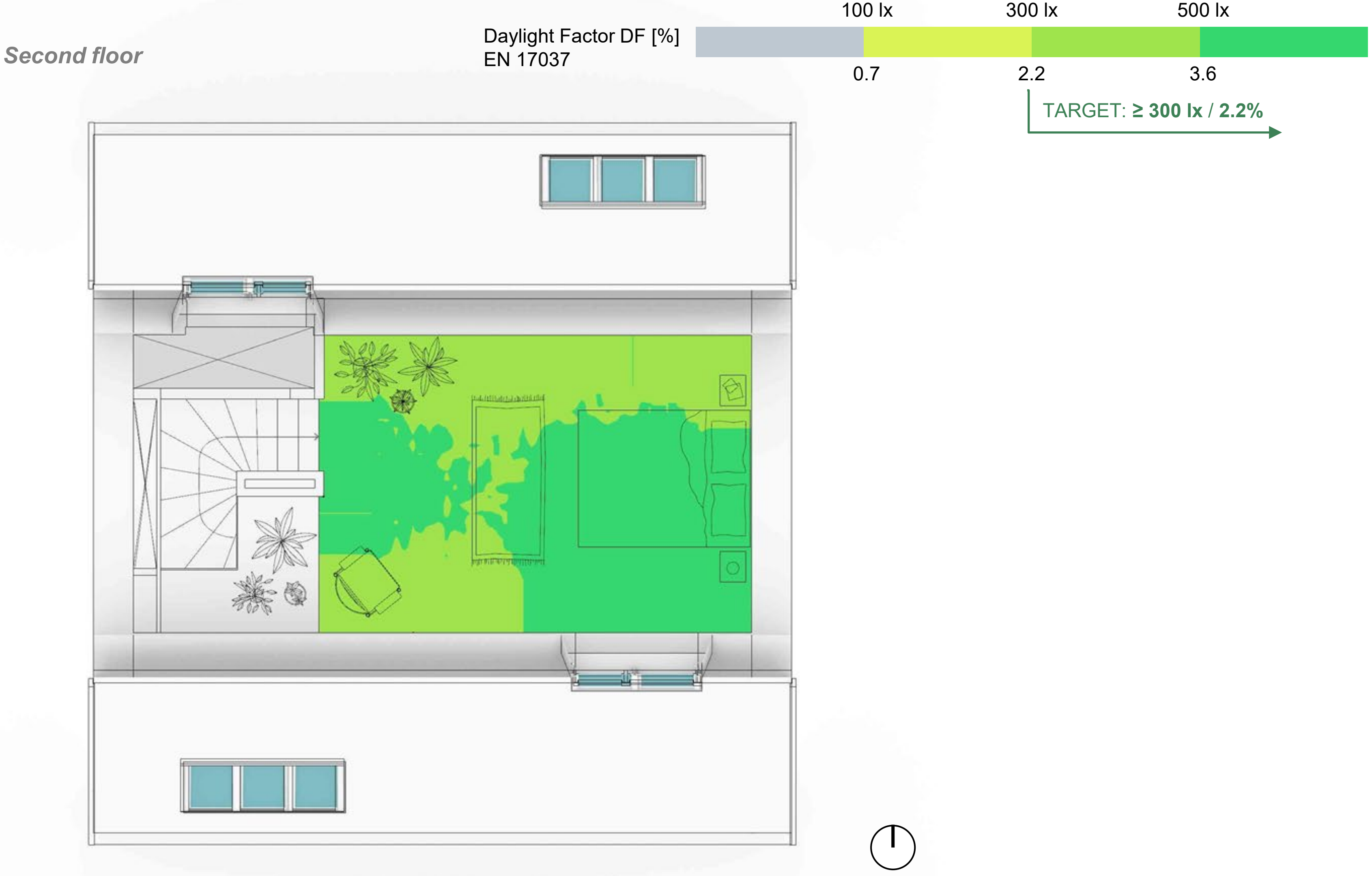
Daylight

Results according EN 17037

Overall area percentage



➔ Target daylight factor $D_T \geq 2.2\%$ is reached for **100% of the occupied space** analyzed.



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Comfort

Thermal environment & Indoor air quality

Thermal modelling

Thermal comfort and indoor air quality assessment

- The thermal modelling for thermal comfort and indoor air quality assessment is done using TRNSYS dynamic simulation software.
- The analysis is made as a single-zone simulation.
- The thermal simulations are based on a weather file from the DWD (Deutscher Wetterdienst) for Frankfurt, reflecting the current climate conditions.
- The boundary conditions, defined in the following section, are intended to represent the actual use of the house.
- The modelling does not include the domestic hot water.

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Thermal comfort summary of the results as per Active House

HYGGE HOUSE

Summer comfort: Maximum operative temperature (without air conditioning)

	Percentage of occupied time (target: minimum 95%)
$T_{i,o} < 0.33 \times T_{rm} + 20.8°C$	87%
$T_{i,o} < 0.33 \times T_{rm} + 21.8°C$	92%
$T_{i,o} < 0.33 \times T_{rm} + 22.8°C$	95%
$T_{i,o} < 0.33 \times T_{rm} + 23.8°C$	97%

Winter comfort: Minimum operative temperature

	Percentage of occupied time (target: minimum 95%)
$T_{i,o} > 21°C$	57%
$T_{i,o} > 20°C$	99%
$T_{i,o} > 19°C$	100%
$T_{i,o} > 18°C$	100%

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Indoor air quality summary of the results as per Active House

HYGGE HOUSE

Standard fresh air supply per room

	Percentage of occupied time (target: minimum 95%)
< 400 ppm above outdoor CO2 concentration	80%
< 550 ppm above outdoor CO2 concentration	100%
< 800 ppm above outdoor CO2 concentration	100%
< 1100 ppm above outdoor CO2 concentration	100%

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House | Comfort

Thermal simulations: thermal environment and IAQ assessment

Geometry & envelope

Area (modelled NGF)	198 m²
Volume	344 m³
Orientation	Sloped roof oriented North-South
Location	Frankfurt, Germany

Opaque constructions

Floor to ground	Light weight construction	U = 0.10 W/m²K		
External walls	Light weight construction	U = 0.11 W/m²K		
Roof		Light weight construction		U = 0.10 W/m²K

Windows

Sloped roof windows	Glazing	Ug = 1.0 W/m²K Tvis = 66% g-value = 46%
	Frame	26% frame factor Uf = 2.0 W/m²K
Flat roof windows	Glazing	Ug = 0.60 W/m²K Tvis = 63% g-value = 49%
	Frame	10% frame factor Uf = 1.2 W/m²K
Vertical windows	Glazing	Ug = 0.6 W/m²K Tvis = 70% g-value = 49%
	Frame	10% frame factor Uf = 1.2 W/m²K

Solar protection	External shutters on roof windows, controlled according to solar radiation received on window Sloped roof windows shutters: fc = 80% Flat roof windows: fc = 80%

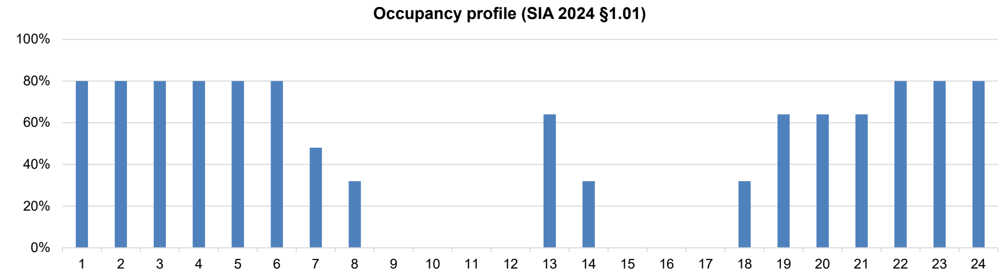
Active House | Comfort

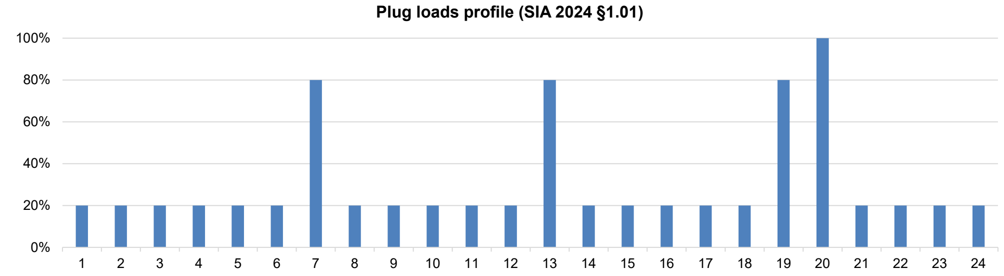
Thermal simulations: thermal environment and IAQ assessment

HYGGE HOUSE

Internal Gains

People	Sensible loads 70 W/pers Latent loads 50 W/pers (80 g/h) 3 people Profile occupancy
Artificial lighting	5 W/m² Control based on occupancy and daylight
Plug loads	5 W/m² Profile plug loads



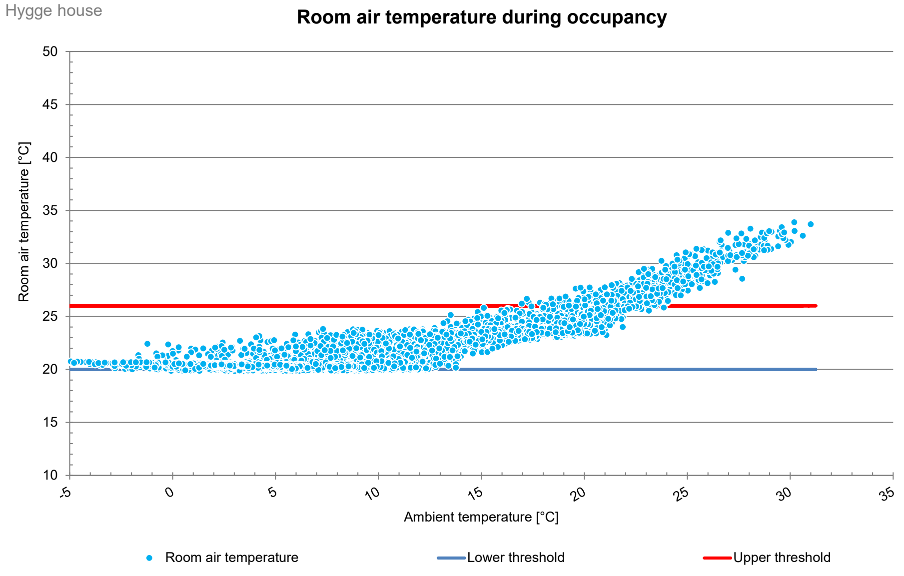


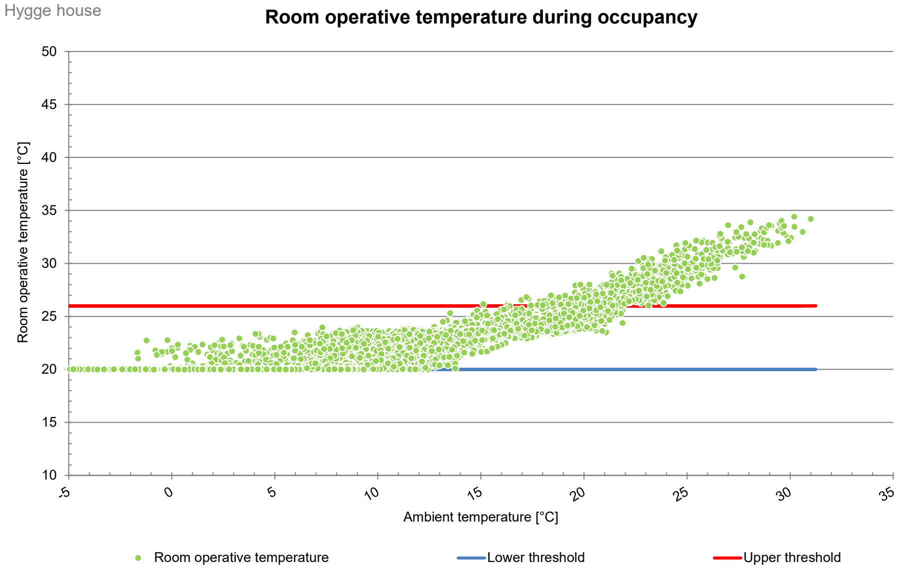
Room conditions

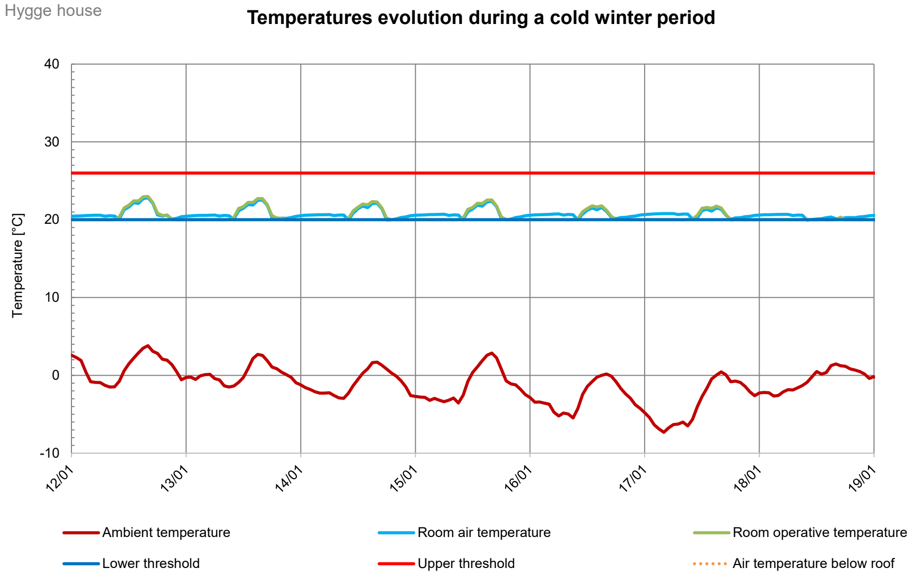
Room conditions	Heating setpoint 20°C min. operative temperature No active cooling	
Ventilation strategy	Natural ventilation	50 m³/h
	Supply air temperature	20°C or Tamb depending on outdoor temperature in hybrid mode
	no humidification / no dehumidification HR sensible = 80% HR latent = 0%	
Infiltration	0.15 ACR	

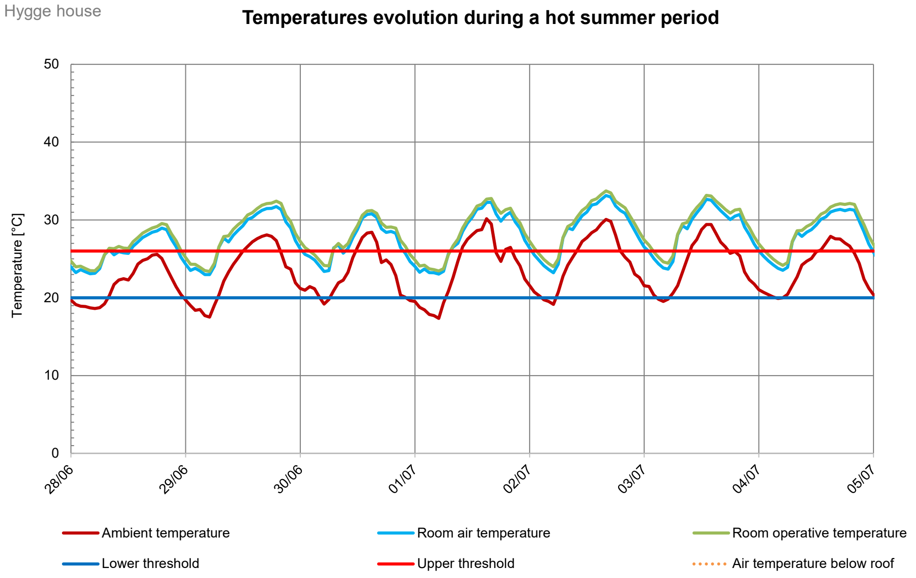
Active House | Comfort

Thermal simulations: thermal environment and IAQ assessment



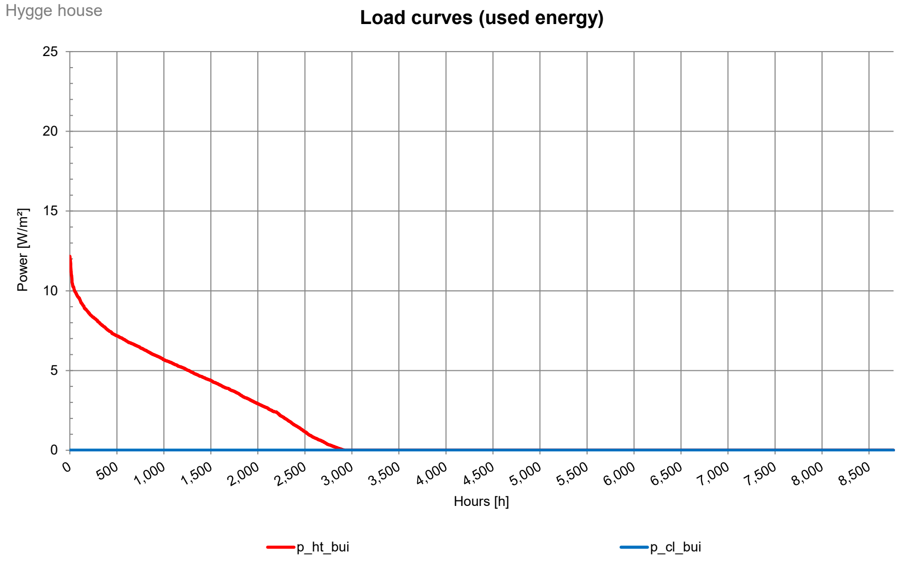


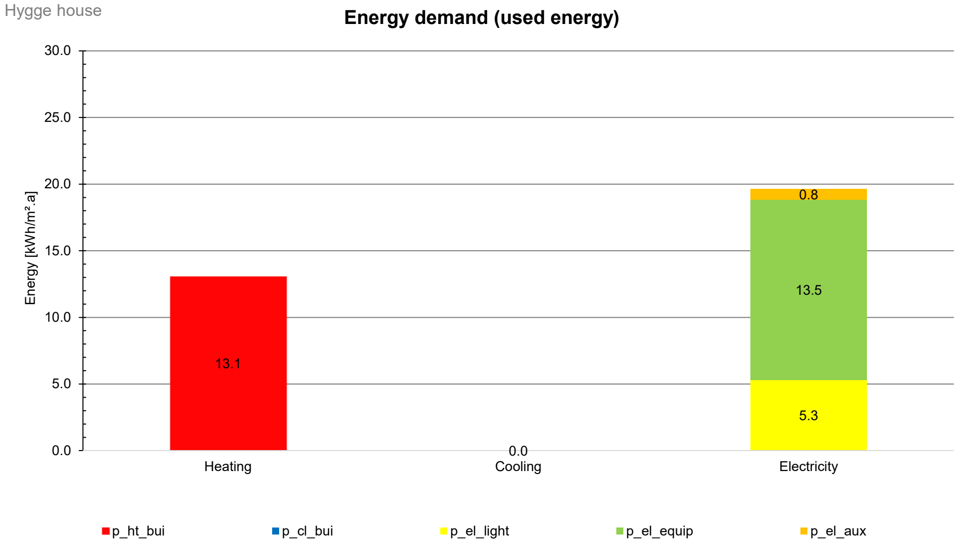




Active House | Comfort

Thermal simulations: thermal environment and IAQ assessment



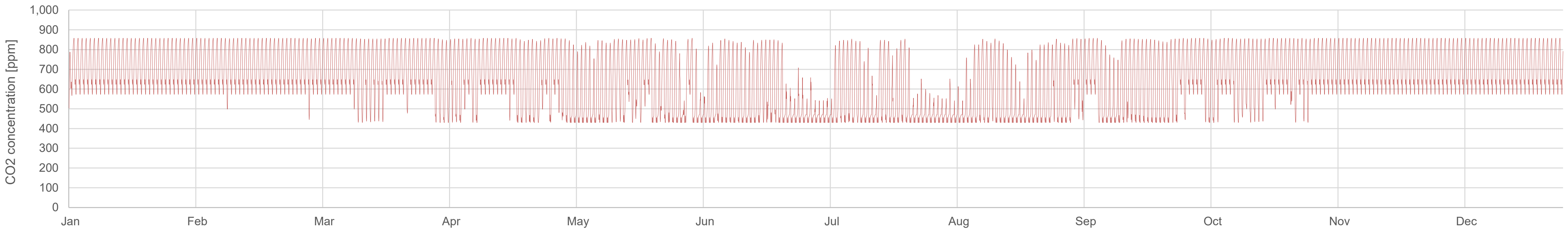


p_ht_bui: heating
p_cl_bui: cooling
p_el_light: electricity for artificial lighting
p_el_equip: electricity for electrical equipments
p_el_aux: auxiliary electricity

Active House | Comfort

Thermal simulations: thermal environment and IAQ assessment

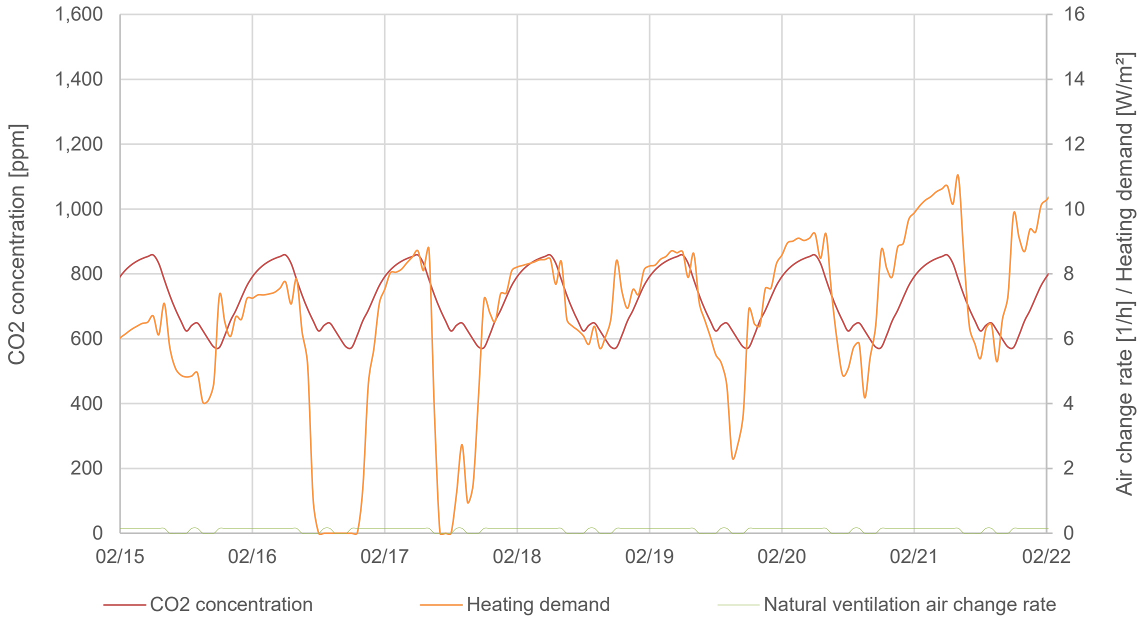
Annual CO2 concentration



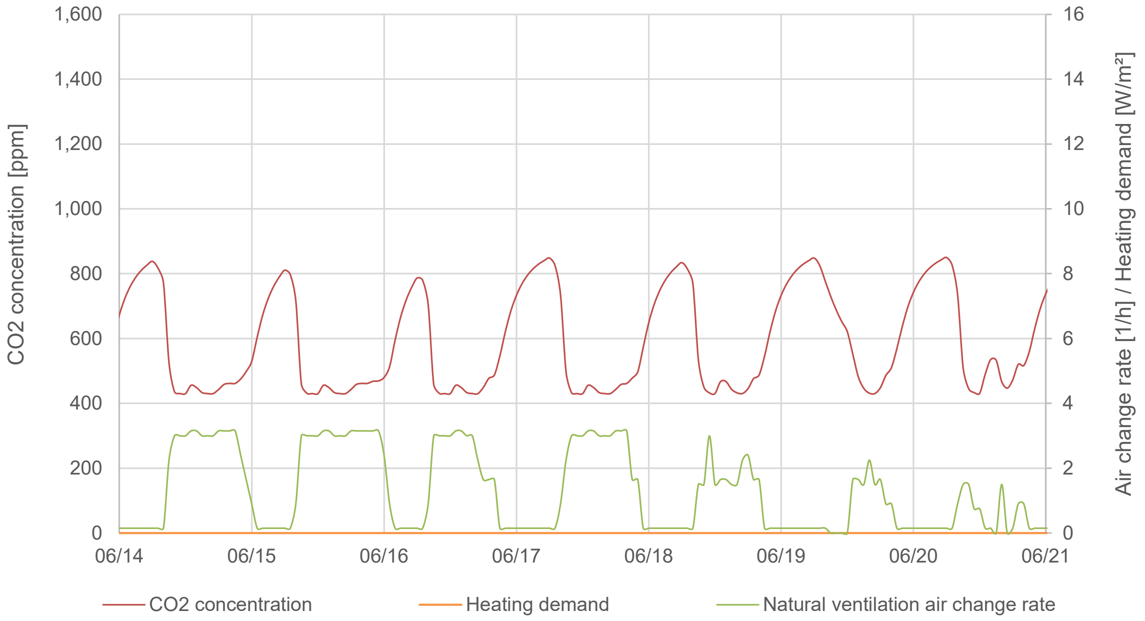
➔ Maximum indoor CO_2 level: 858 ppm, being 428 ppm above outdoor level

➔ Average indoor CO_2 level over the year: 652 ppm

Typical winter week



Typical summer week



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Energy

Energy demand, Energy supply, Primary energy

GEG Calculations

- The GEG calculations are calculated using the software ZUB Helena. The geometry is entered using the 3D-input using E-CAD 6 Pro.
- The GEG Calculation uses a German-standard-weather and not local weather files.
- A lot of the inputs are standardized as this calculation is meant as a comparison tool to evaluate buildings in Germany.
- The calculation does not include electricity that is not necessary to operate the building. The electricity demand for lighting is also not considered.
- The ventilation rates in residential buildings are defined by set values and can not be changed. Only the tightness of the building which influences the infiltration can be defined.

Energy Demand & Supply

Variants list

With the first planning of the building, we fulfill the requirements of the “GebäudeEnergieGesetz” (GEG – legal standard) but we don´t fulfill the stricter requirements for the “Bundesförderung für effiziente Gebäude” (BEG – funded efficient building standard). The EH 40 is a building standard that the building has to reach to acquire the BEG funding.

Therefor we created Variants to show possible improvements.

The BEG has a requirement for the envelope of the building and a requirement for the primal energy demand of the building.

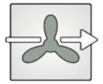
variant	envelope	ventilation	Photovoltaik	Building Standard achieved
V0	According to planing	Natural ventilation	11 sqm of PV	Only GEG
V1	According to BEG40	Natural ventilation	11 sqm of PV	GEG + Only envelope according to EH 40
V2	According to BEG40	Mechanical ventilation	11 sqm of PV	GEG + EH 40
V3	According to BEG40	Natural ventilation	11 sqm of PV + 20 sqm of PV	GEG + EH 40
V4	According to BEG40	Mechanical ventilation	11 sqm of PV + 20 sqm of PV	GEG + EH 40

Energy Demand & Supply

Variant 0 – base

HYGGE HOUSE

External wall:	area =	168 m²	U-value = 0,15 W/m²K	A_{NGF} = 103 m²
Ground slab:	area =	65 m²	U-value = 0,17 W/m²K	A/V = 79%
Roof sloped:	area =	78 m²	U-value = 0,13 W/m²K	thermal bridges = 0,05 W/m²K
Roof flat:	area =	12 m²	U-value = 0,13 W/m²K	
Window	area =	12 m²	U-value = 0,66 W/m²K	g-value = 49 %
Window_sloped	area =	17 m²	U-value = 1,3 W/m²K	g-value = 46 %
Window_flat	area =	2,4 m²	U-value = 0,73 W/m²K	g-value = 49 %



ventilation: natural ventilation through windows

Heating: air-water-heat pump
radiators

Cooling: no cooling

Domestic hot water: electric direct heater

Photovoltaik: 11 m² on the flat roof

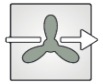
Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Energy Demand & Supply

Variant 1 – envelope according to EH 40

HYGGE HOUSE

• External wall:	area =	168 m²	U-value = 0,13 W/m²K	A_{NGF} = 103 m²
• Ground slab:	area =	65 m²	U-value = 0,14 W/m²K	A/V = 79%
• Roof sloped:	area =	78 m²	U-value = 0,13 W/m²K	thermal bridges = 0,03 W/m²K
• Roof flat:	area =	12 m²	U-value = 0,13 W/m²K	
• Window	area =	12 m²	U-value = 0,66 W/m²K	g-value = 49 %
• Window_sloped	area =	17 m²	U-value = 0,90 W/m²K	g-value = 46 %
• Window_flat	area =	2,4 m²	U-value = 0,73 W/m²K	g-value = 49 %



ventilation: natural ventilation through windows

Heating: air-water-heat pump radiators

Cooling: no cooling

Domestic hot water: electric direct heater

Photovoltaik: 11 m² on the flat roof

Energy Demand & Supply

Variant 2 – envelope according to EH 40 + mechanical Ventilation with heat recovery

HYGGE HOUSE

• External wall:	area =	168 m²	U-value = 0,13 W/m²K	A_{NGF} = 103 m²
• Ground slab:	area =	65 m²	U-value = 0,14 W/m²K	A/V = 79%
• Roof sloped:	area =	78 m²	U-value = 0,13 W/m²K	thermal bridges = 0,03 W/m²K
• Roof flat:	area =	12 m²	U-value = 0,13 W/m²K	
• Window	area =	12 m²	U-value = 0,66 W/m²K	g-value = 49 %
• Window_sloped	area =	17 m²	U-value = 0,90 W/m²K	g-value = 46 %
• Window_flat	area =	2,4 m²	U-value = 0,73 W/m²K	g-value = 49 %

ventilation: mechanical ventilation (Supply + Exhaust) with heat recovery

Heating:	air-water-heat pump radiators
Cooling:	no cooling
Domestic hot water:	electric direct heater
Photovoltaik:	11 m² on the flat roof

Energy Demand & Supply

Variant 3 – envelope according to EH 40 + additional PV

HYGGE HOUSE

• External wall:	area =	168 m²	U-value = 0,13 W/m²K	A_{NGF} = 103 m²
• Ground slab:	area =	65 m²	U-value = 0,14 W/m²K	A/V = 79%
• Roof sloped:	area =	78 m²	U-value = 0,13 W/m²K	thermal bridges = 0,03 W/m²K
• Roof flat:	area =	12 m²	U-value = 0,13 W/m²K	
• Window	area =	12 m²	U-value = 0,66 W/m²K	g-value = 49 %
• Window_sloped	area =	17 m²	U-value = 0,90 W/m²K	g-value = 46 %
• Window_flat	area =	2,4 m²	U-value = 0,73 W/m²K	g-value = 49 %

ventilation: natural ventilation through windows

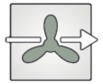
Heating:	air-water-heat pump radiators
Cooling:	no cooling
Domestic hot water:	electric direct heater
Photovoltaik:	11 m² on the flat roof + 20 m² on south roof

Energy Demand & Supply

Variant 4 – envelope according to EH 40 + mechanical Ventilation with heat recovery + additional PV

HYGGE HOUSE

• External wall:	area =	168 m²	U-value = 0,13 W/m²K	A_{NGF} = 103 m²
• Ground slab:	area =	65 m²	U-value = 0,14 W/m²K	A/V = 79%
• Roof sloped:	area =	78 m²	U-value = 0,13 W/m²K	thermal bridges = 0,03 W/m²K
• Roof flat:	area =	12 m²	U-value = 0,13 W/m²K	
• Window	area =	12 m²	U-value = 0,66 W/m²K	g-value = 49 %
• Window_sloped	area =	17 m²	U-value = 0,90 W/m²K	g-value = 46 %
• Window_flat	area =	2,4 m²	U-value = 0,73 W/m²K	g-value = 49 %



ventilation: mechanical ventilation (Supply + Exhaust) with heat recovery

Heating: air-water-heat pump
radiators

Cooling: no cooling

Domestic hot water: electric direct heater

Photovoltaik: 11 m² on the flat roof + 20 m² on south roof

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

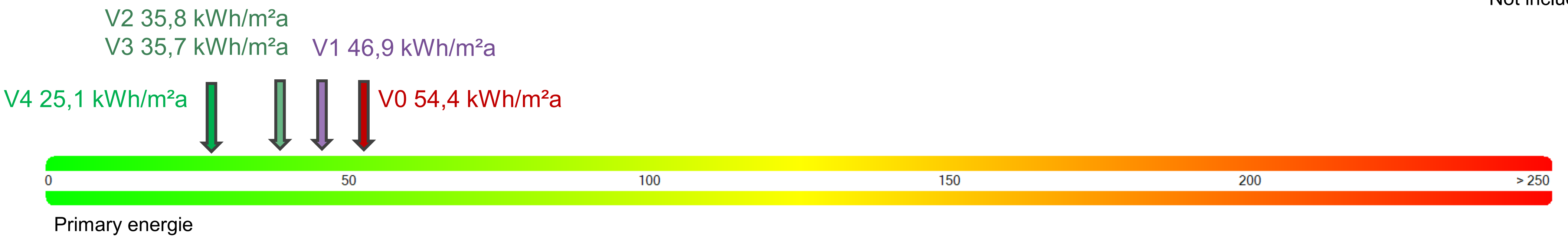
Energy Demand & Supply

HYGGE HOUSE

- Hygge house results:
  - spez. final energy
  - spez. primary energy
  - spez. CO2-Equivalent:

V0	V1	V2	V3	V4
30,2 kWh/m²a	26,0 kWh/m²a	19,9 kWh/m²a	19,8 kWh/m²a	13,9 kWh/m²a
54,4 kWh/m²a	46,9 kWh/m²a	35,8 kWh/m²a	35,7 kWh/m²a	25,1 kWh/m²a
16,9 kg/m²a	14,6 kg/m²a	11,1 kg/m²a	11,1 kg/m²a	7,8 kg/m²a

*Including PV Offset
Not including User Energy



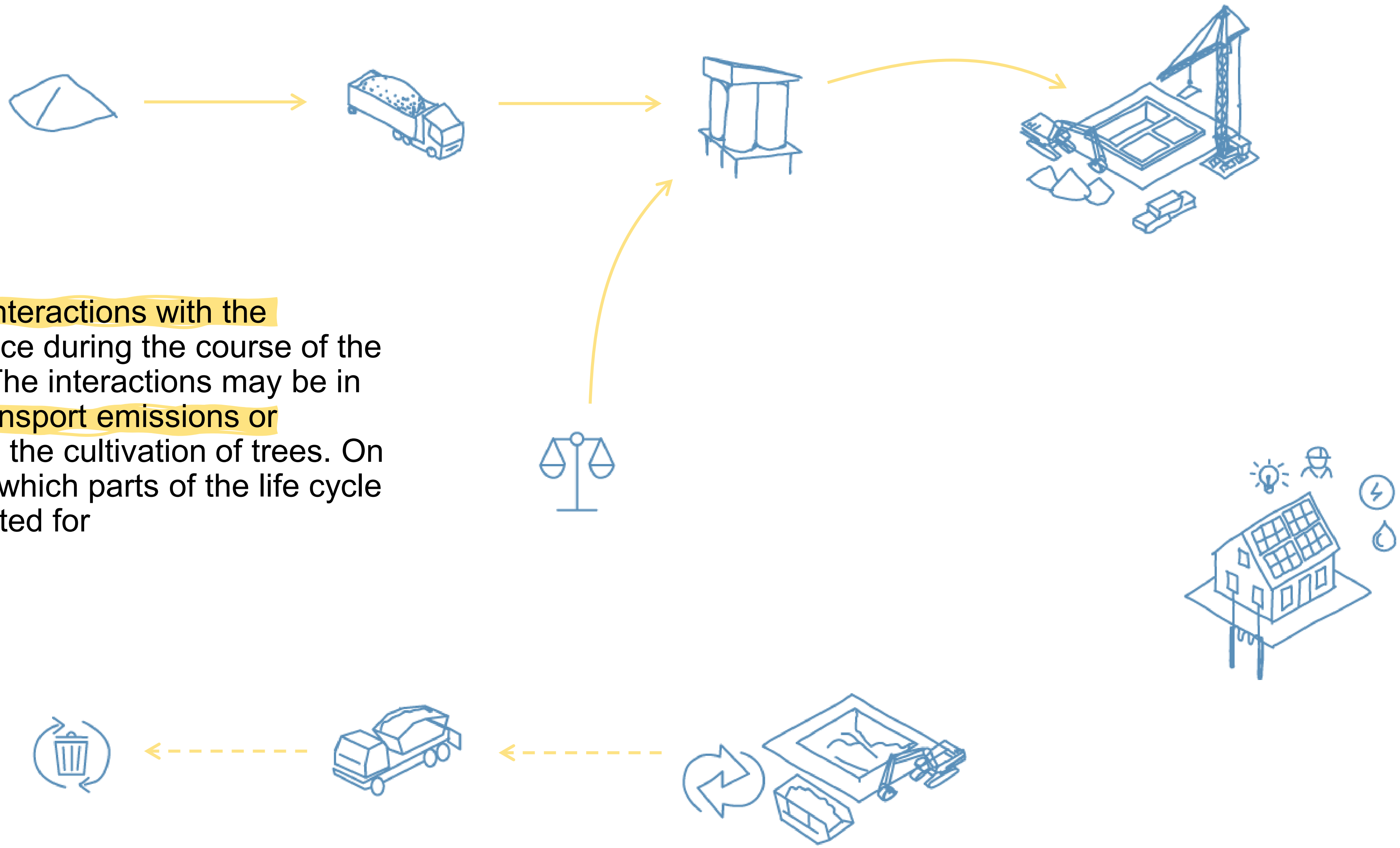
The GEG for residential buildings includes only the energy demand of heating, cooling, ventilation and hot water. The energy demand for lighting and plug loads is not included.

Environment

Sustainable construction

Life Cycle Analysis

Why do we perform a LCA?



An LCA adds up all of the interactions with the environment which take place during the course of the included life cycle stages. The interactions may be in the form of for example, transport emissions or resource consumption from the cultivation of trees. On the next page you can see which parts of the life cycle of the materials are accounted for

Life Cycle Analysis

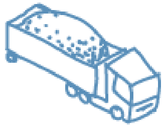
What are the phases included in the LCA?

Product stage

A1

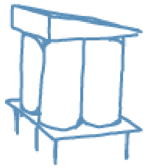
Raw material

A2



Raw material

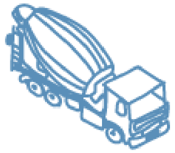
A3



Manufacturing

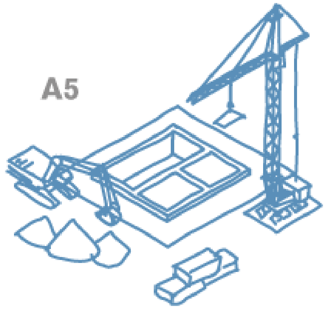
Construction process stage

A4



Transport

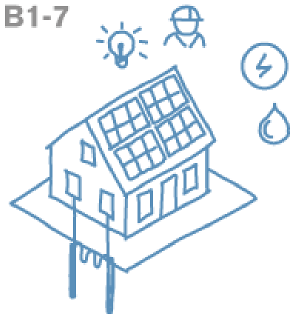
A5



Construction

Use stage

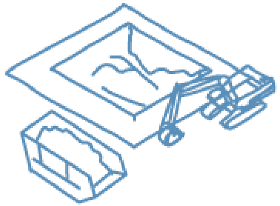
B1-7



B1 Use
B2 Maintenance
B3 Repair
B4 Replacement
B5 Refurbishment
B6 Energy use
B7 Water use

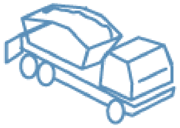
End of life stage

C1



Deconstruction

C2



Transport

C3

Waste processing

C4

Disposal

Benefits and loads beyond the system boundary

D

Reuse, recovery and recycling potetial

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Life Cycle Analysis
In the german market

A series of Life Cycle Assessment (LCA) studies were performed to evaluate the performance of the Hygge House in Germany. To enable a comparison with a typical German house, the research also included a standard building model based on designs from the architectural firm DGJ Architektur.

- Hygge House modeled following the QNG guidelines
- Hygge House modeled following the DGNB standards

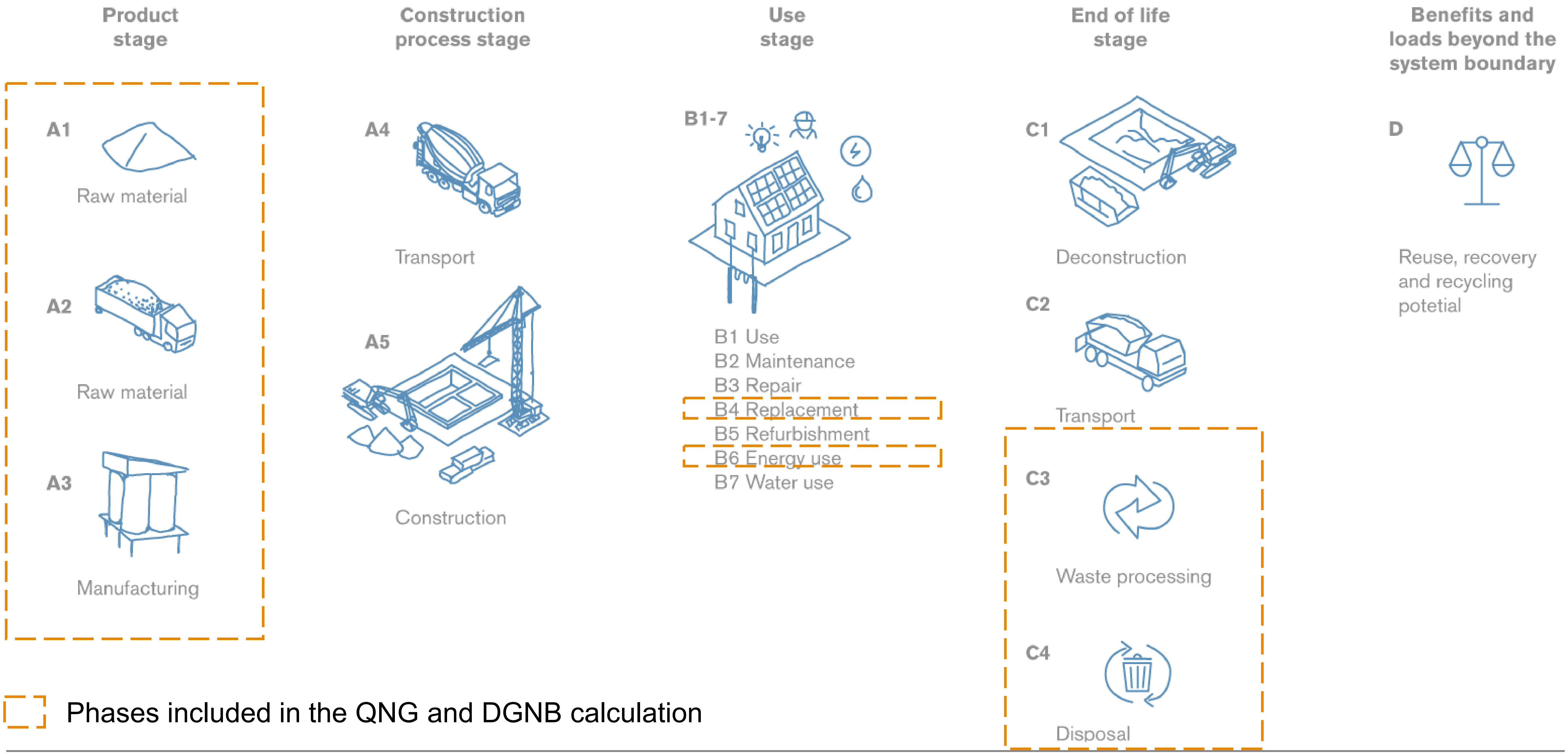
These two certification frameworks were chosen because of their relevance to the German market. DGNB is a Europe-wide sustainability certification commonly used for larger and mixed-use developments, while QNG is applied primarily when seeking public funding, with a particular emphasis on residential buildings.

Topic	DGNB	QNG
	DGNB	NACHHALTIGES GEBÄUDE
Evaluation logic	Relative (Reference House)	Absolute (thresholds)
Flexibility	High	Low, fixed structure for the evaluation
Database	EPD + project-specific until v.2018, from v.2023 only Ökobau.dat	Standardized only - Based on its own database, no EPD included
Goal	Optimization	Compliance
Result	Score (Silver–Platinum)	Pass/Fail
Phases of the LCA included	A1-A3, B4, B6, C3.C4, D	A1-A3, B4, B6, C3.C4
Utilisation of ecological materials	Advantage	No bonus
Role of LCA	One criterion among many, with associated points according to the complexity	Central requirement
Normalised emissions	NRF excluding garage	NRF

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Life Cycle Analysis

What are the phases included in the LCA?



Phases included in the QNG and DGNB calculation

Life Cycle Analysis

In the german market

Per the DIN276 standard, building costs in Germany are categorized into organized cost groups. The most significant and pertinent groups for this analysis include:

KG 300 – Building Construction (Baukonstruktionen)

This includes all structural and architectural building elements

- Excavation / earthworks (KG 310)
- Foundations (KG 320)
- Exterior walls (KG 330)
- Interior walls (KG 340)
- Floors / slabs (KG 350)
- Roofs (KG 360)

KG 400 – Technical Systems (Technische Anlagen)

All mechanical, electrical, and plumbing systems

- Wastewater, water, and gas systems (KG 410)
- Heating systems (KG 420)
- Ventilation / HVAC systems (KG 430)
- Electrical installations (KG 440)
- Conveying systems (elevators, etc.) (KG 460)
- Building automation (KG 480)

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

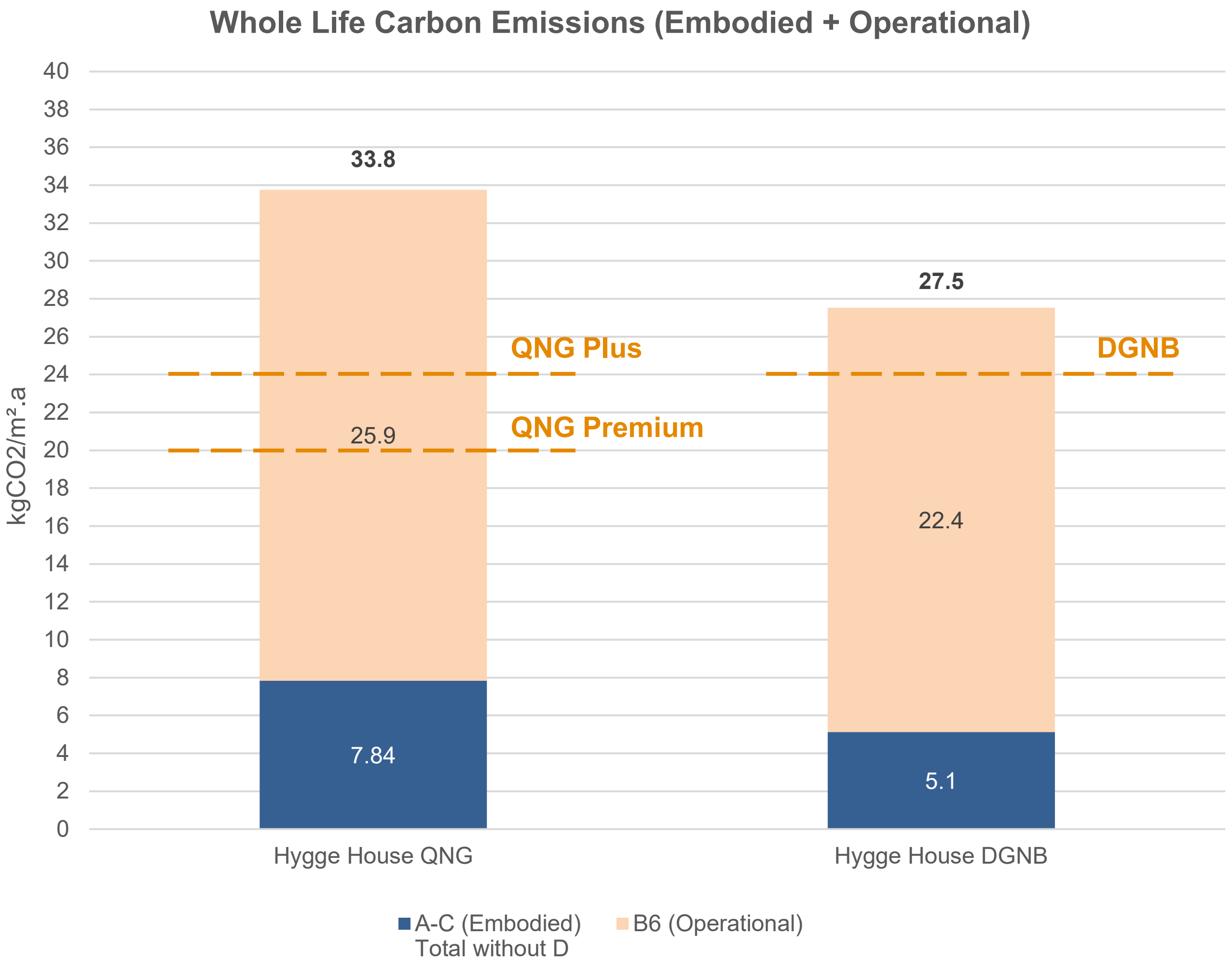
Conclusions | LCA

Whole life carbon emissions in comparison

The results show a consistent trend in both QNG and DGNB calculations. The Hygge Haus performs moderately, staying above the reference values but relatively close to the limits.

Main differences between the two calculation methods are:

- The emission factor for the energy grid:
    - DGNB Electricity Factor: according to Ökobau.dat 2023, 0.465 kgCO2/kWh
    - QNG Electricity Factor: according to the QNG-Table 0.532 kgCO2/kWh
- PV Panels emission, not associated to a specific EPD rather to a generic source (Ökobau.dat/QNG-Table)

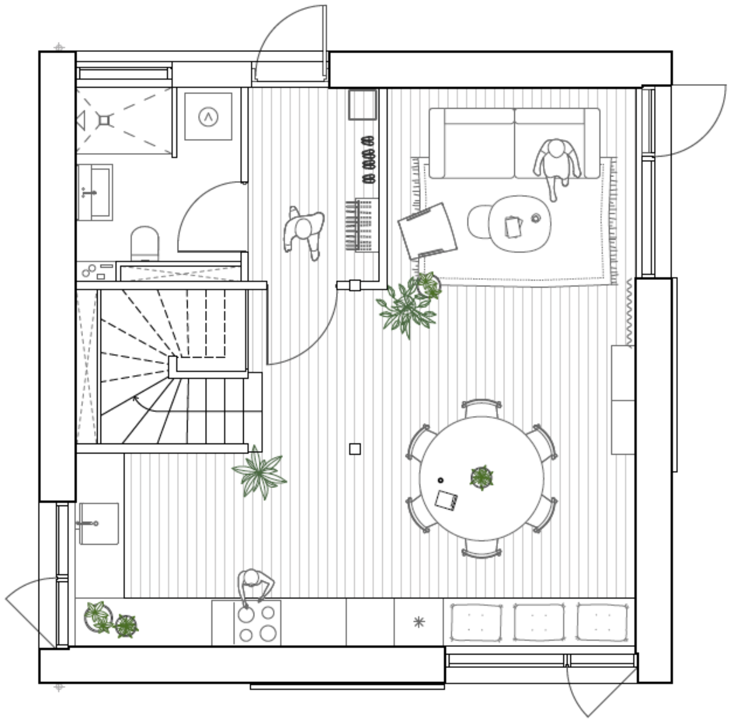


HYGGE HOUSE

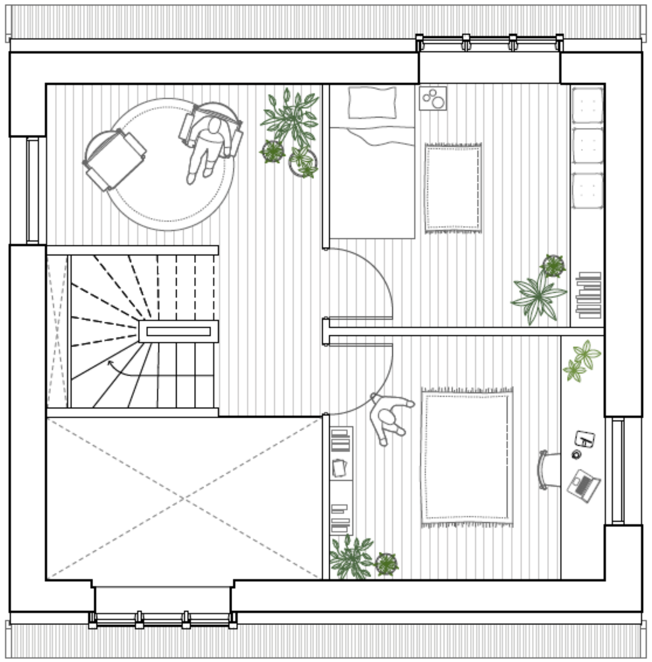
Elements of Construction and results, embodied carbon

Hygge House | LCA

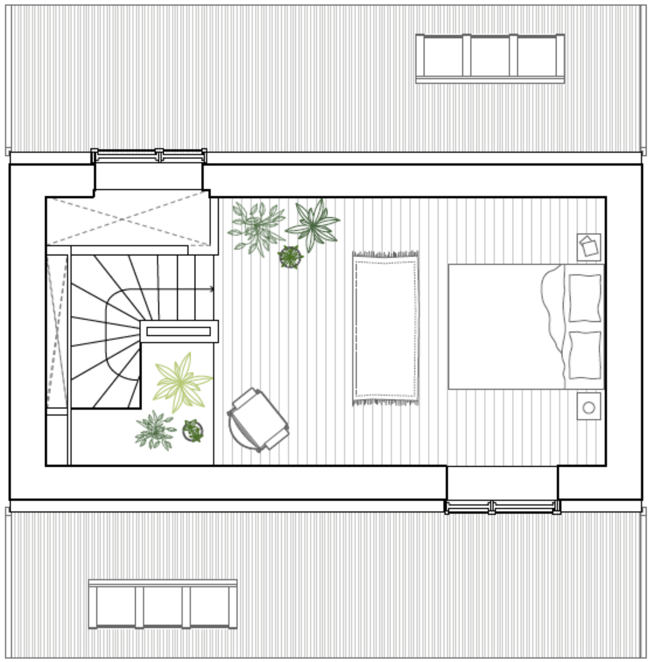
Boundary conditions: floor plans



GROUND FLOOR



FIRST FLOOR



SECOND FLOOR

0 1 2,5 5
Scale 1:50

Net area used for the analysis 130 m^2.

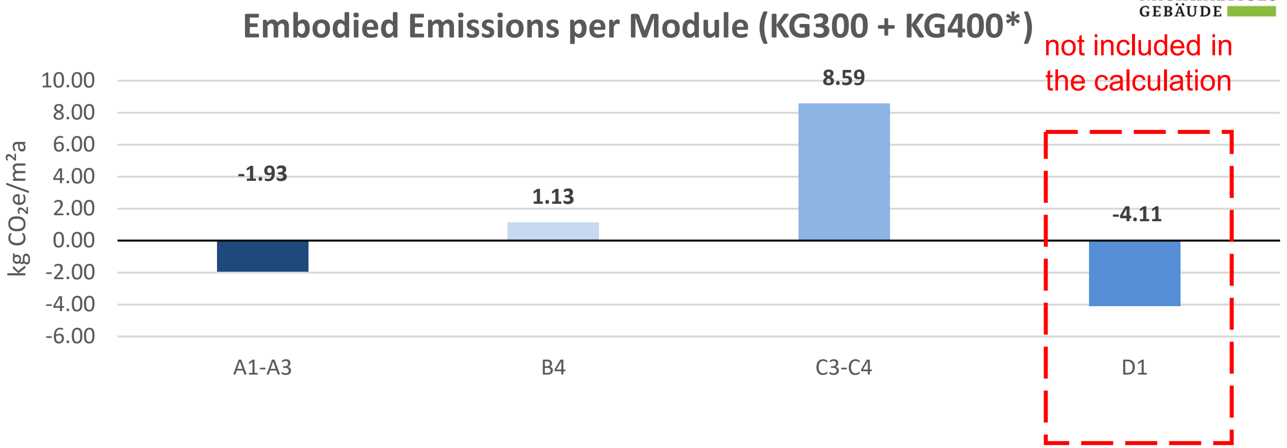
Hygge House | LCA

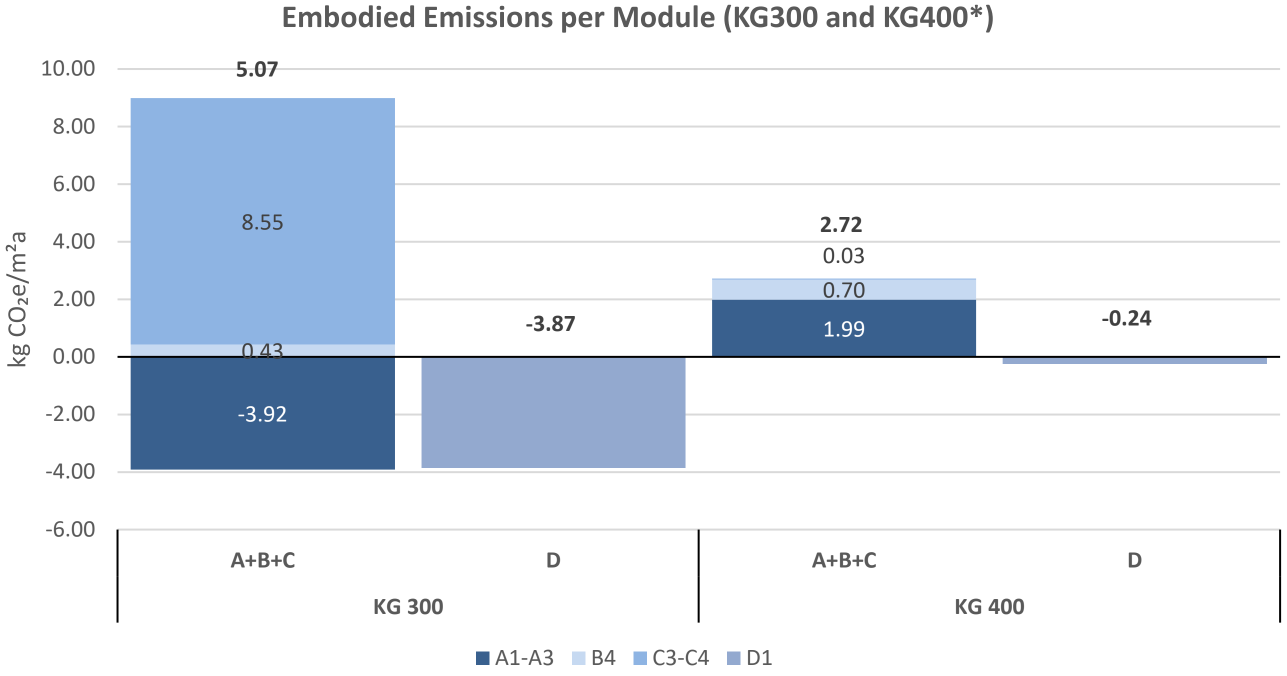
Embodied emissions according to the QNG Framework

These tables present the emissions categorized by cost group and life cycle phase. In accordance with the QNG methodology, module D is not included in the total calculation.

Based on this, the total emissions can be interpreted as follows:

A1-A3, B4, C2-C3: **7.84 kgCO2/m².a**





*KG300 – Construction materials
KG400 – Technical components

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

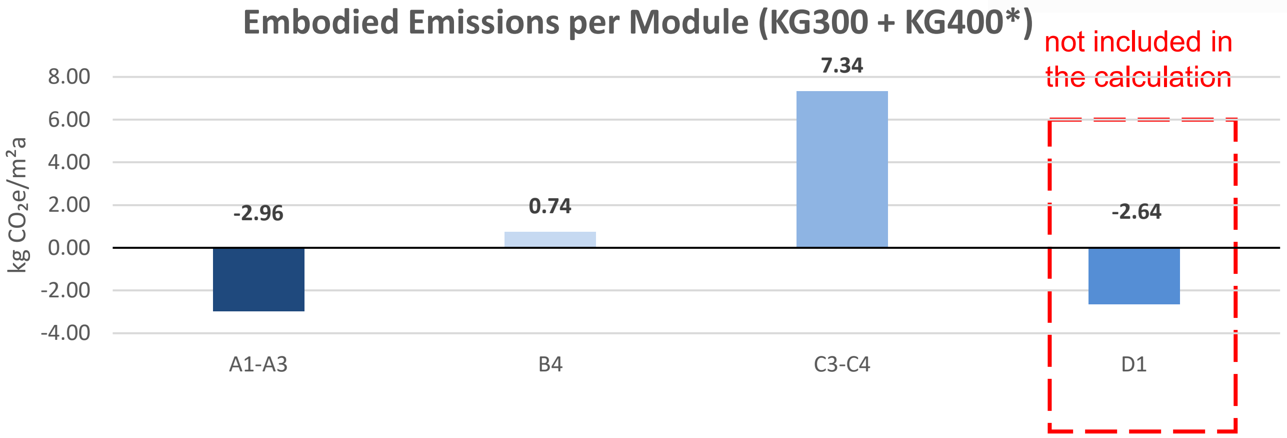
Hygge House | LCA

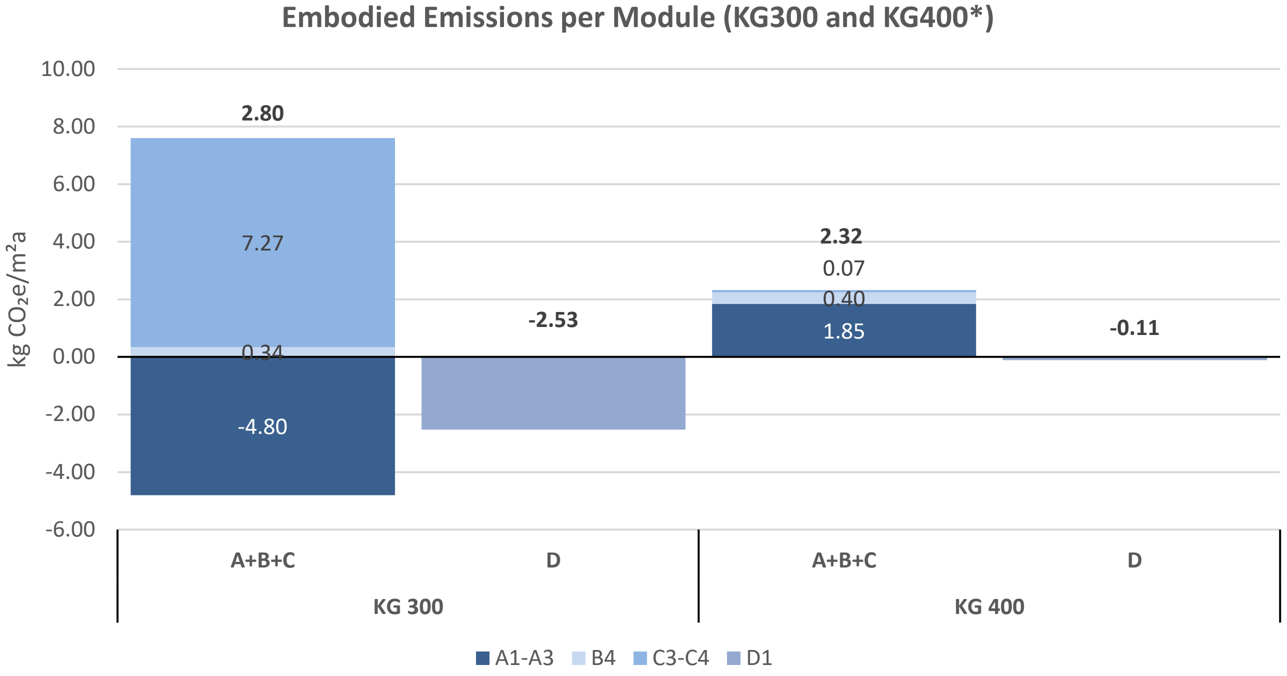
Embodied emissions according to the DGNB Framework

These tables present the emissions categorized by cost group and life cycle phase. In accordance with the DGNB methodology, module D is also not included in the total calculation.

Based on this, the total emissions can be interpreted as follows:

A1-A3, B4, C2-C3: **5.12 kgCO2/m².a**





*KG300 – Construction materials
KG400 – Technical components

Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Hygge House | LCA

Contribution of each material in carbon emissions

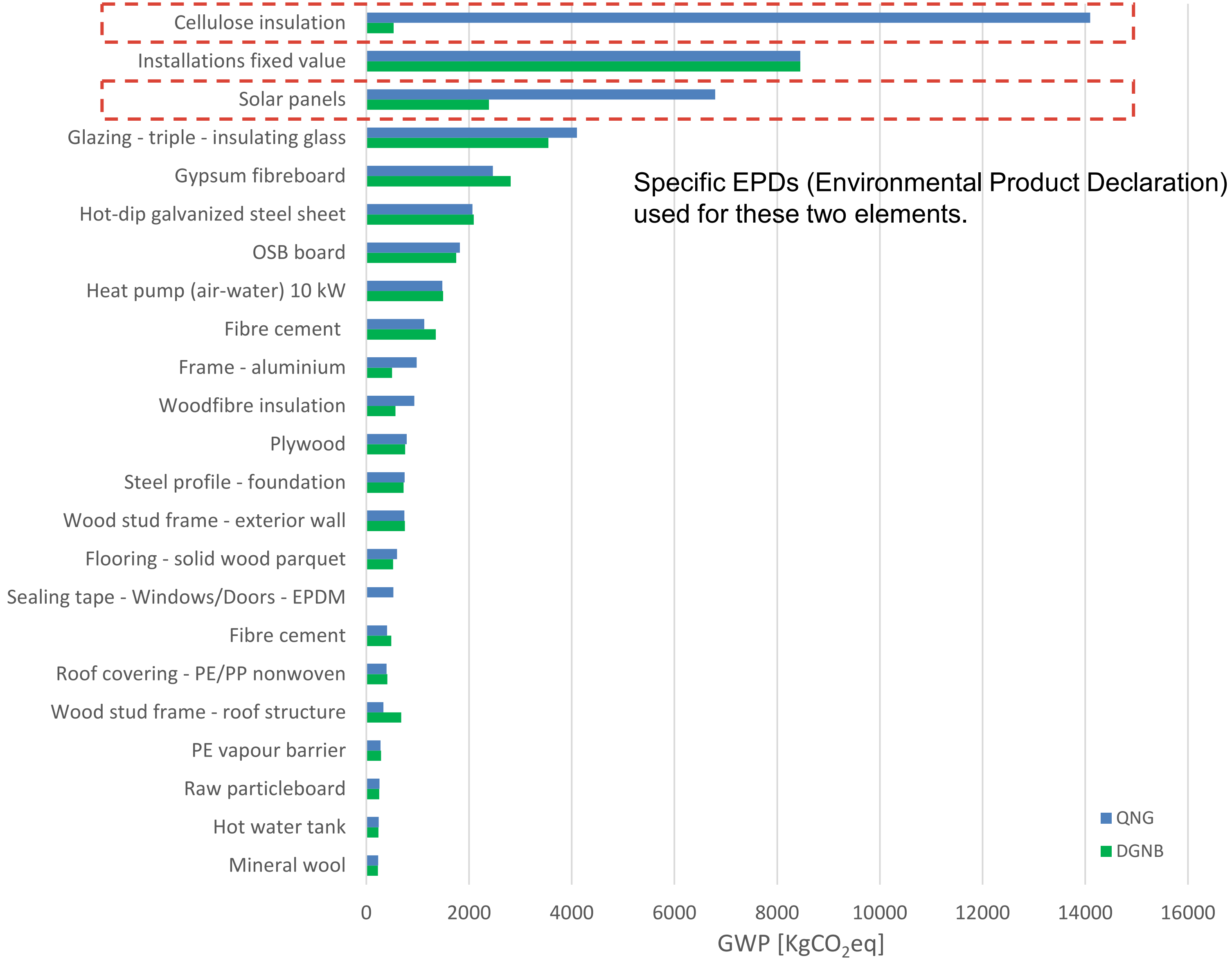
This table organizes the construction elements included in the calculation according to their embodied carbon emissions and their relative percentage contribution.

The performance of most of the materials components is very similar in the QNG and DGNB except the photovoltaic system and cellulose insulation.

For these two components, the more limited QNG material database did not allow using the actual product, while the DGNB methodology allowed using the actual Environmental Product Declaration (EPD).

The cellulose insulation material used in DGNB was made of recycled content which considerably reduced the carbon footprint of this construction element.

The carbon emission for solar panels in QNG is quite high compared to some of the products available in the market. For DGNB, a lower emission product was selected.



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

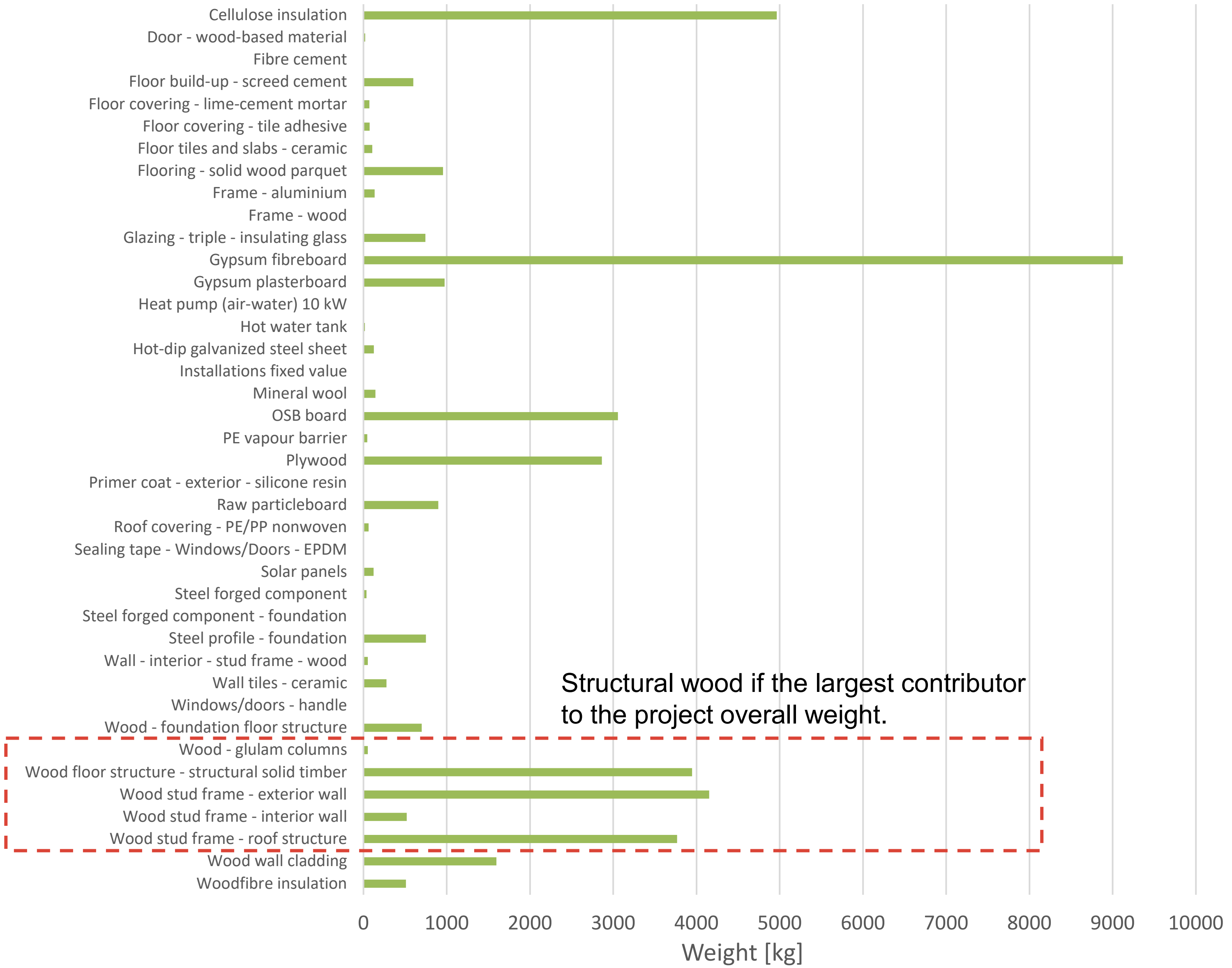
Hygge House | LCA

Contribution of each material in weight

This table arranges the construction elements considered in the calculation based on their weight and percentage representation.

It is evident from the table that concrete and its derivatives are the most prevalent materials used in the building.

.

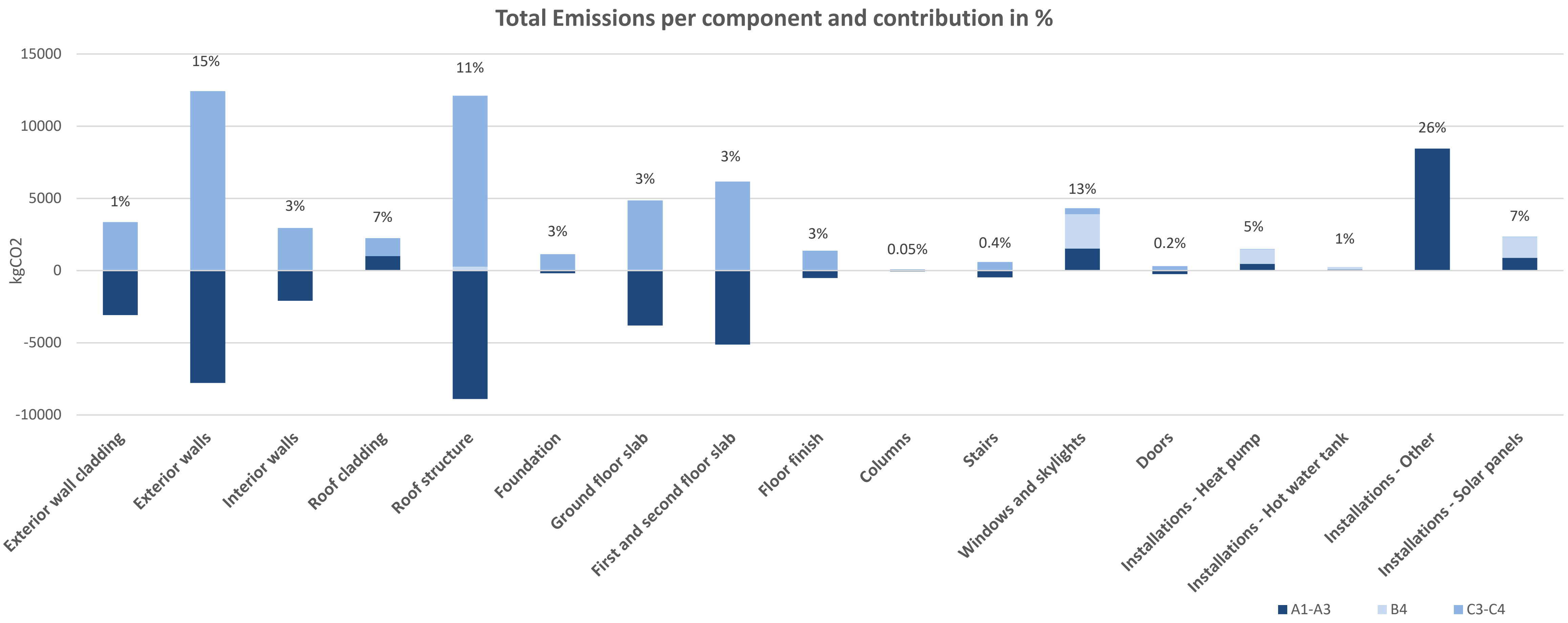


Hygge House | LCA

Embodied emissions per building component according to QNG

Here the largest components in the building are presented according to ist normalised emissions, subdivided into the phases of the life-cycle. Note that the obligatory value for the Technical Components (1.3kgCO2/m².a) is integrated into the phase A1-Ae3 of the element „Installation - Other“.

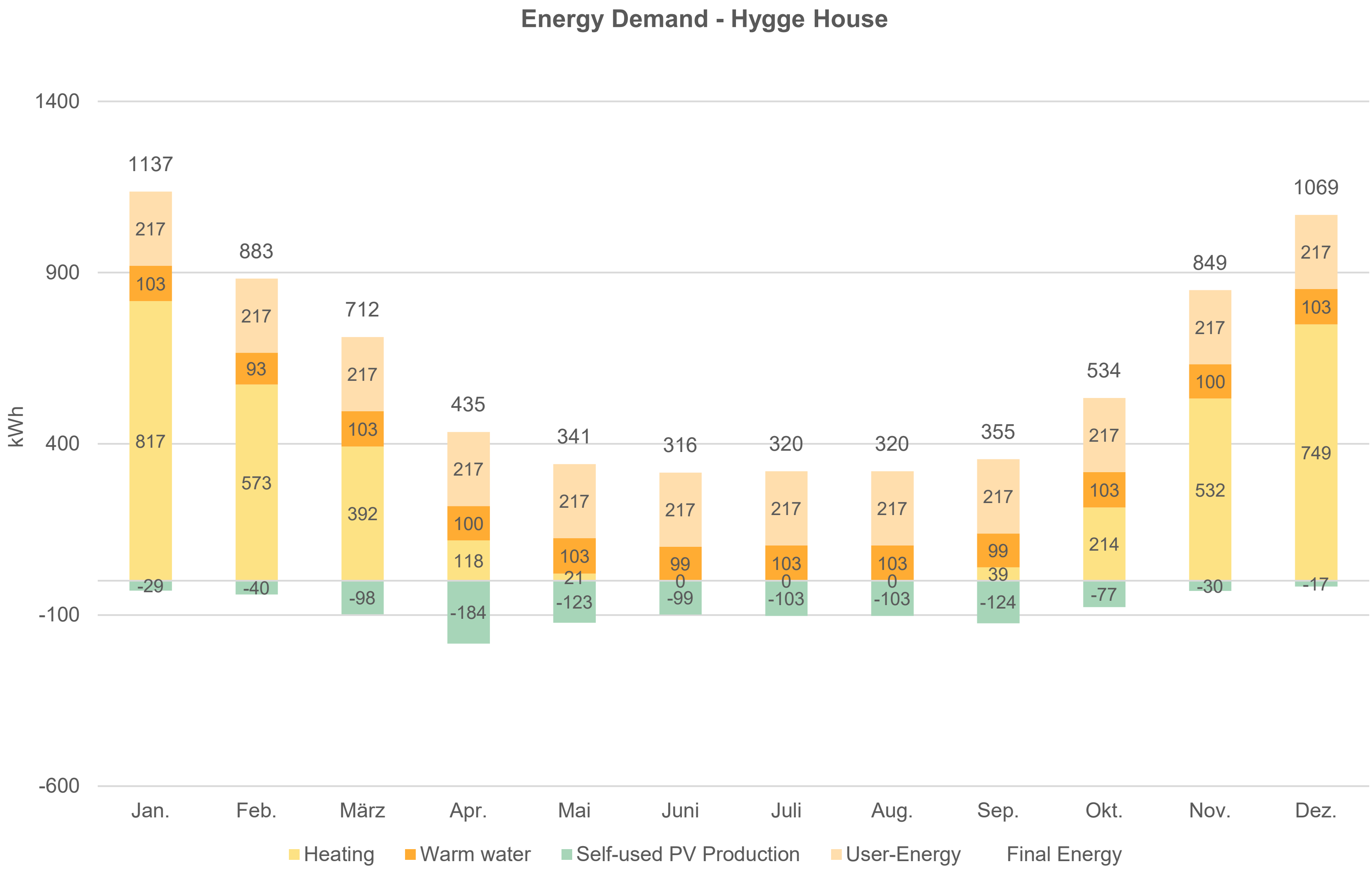
The exterior walls comprise the structural parts and finishing.



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Hygge House | LCA

Operational carbon V0



Self-Consumed and Generated Energy
Total self-used PV: **1027 kWh**
Total produced PV energy: 1450 kWh
Share of self-generated energy: **87.7%**

Hygge House | LCA

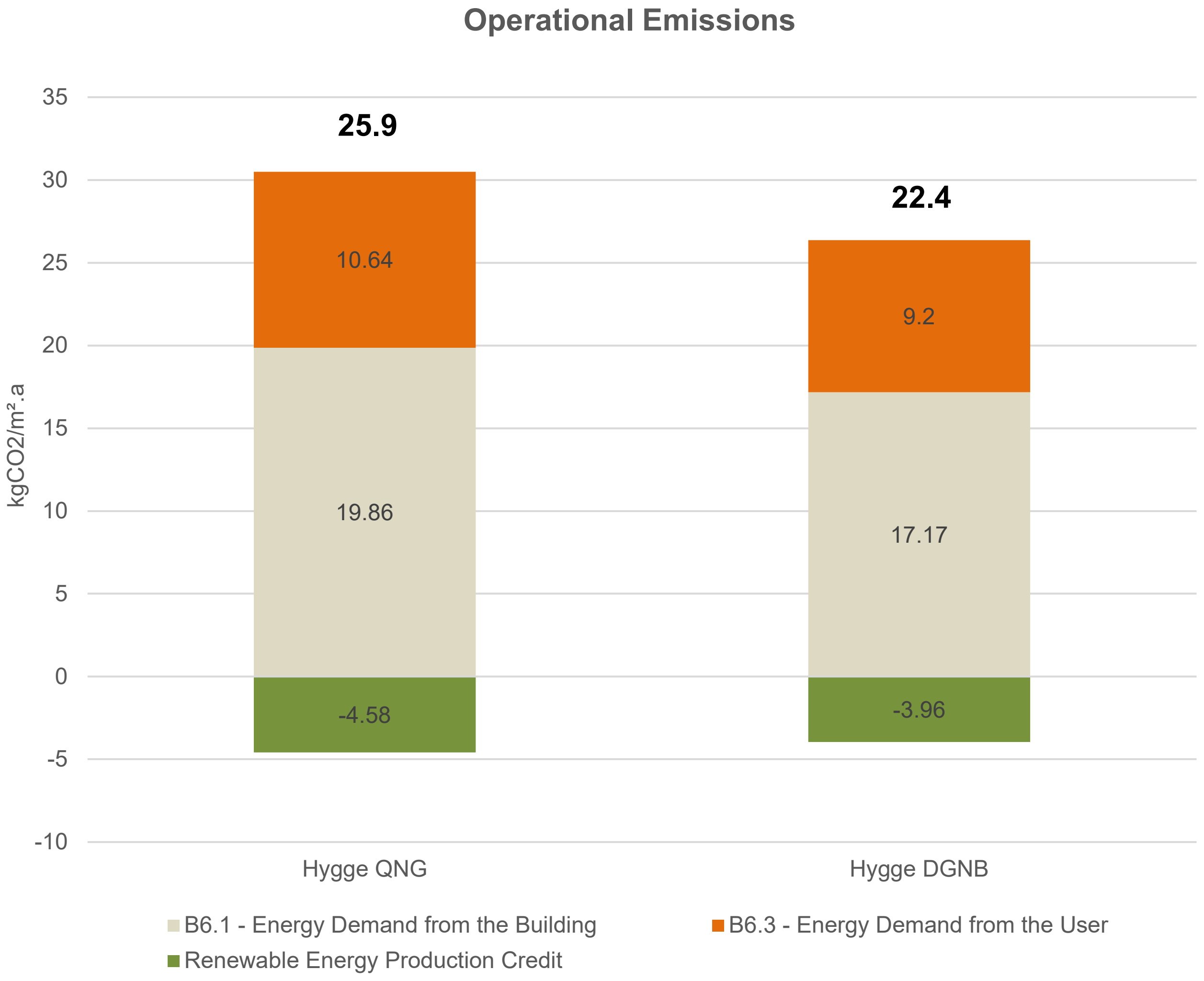
Operational carbon

Operational emissions differ according to the evaluation system, mainly because each system applies distinct carbon emission factors.

For the DGNB system, the electricity emission factor is derived from the German database Ökobau.dat version 2023, which assigns emissions of 0.465 $kgCO_2$ per kWh.

On the other hand, the QNG system relies on the QNG database "Oekobilanzierung Rechenwerte 2023," attributing an emission value of 0.532 $kgCO_2$ per kWh.

In both certification schemes, exported energy is excluded from the calculations, meaning, operational emissions cannot be lowered by accounting for energy fed back into the grid.



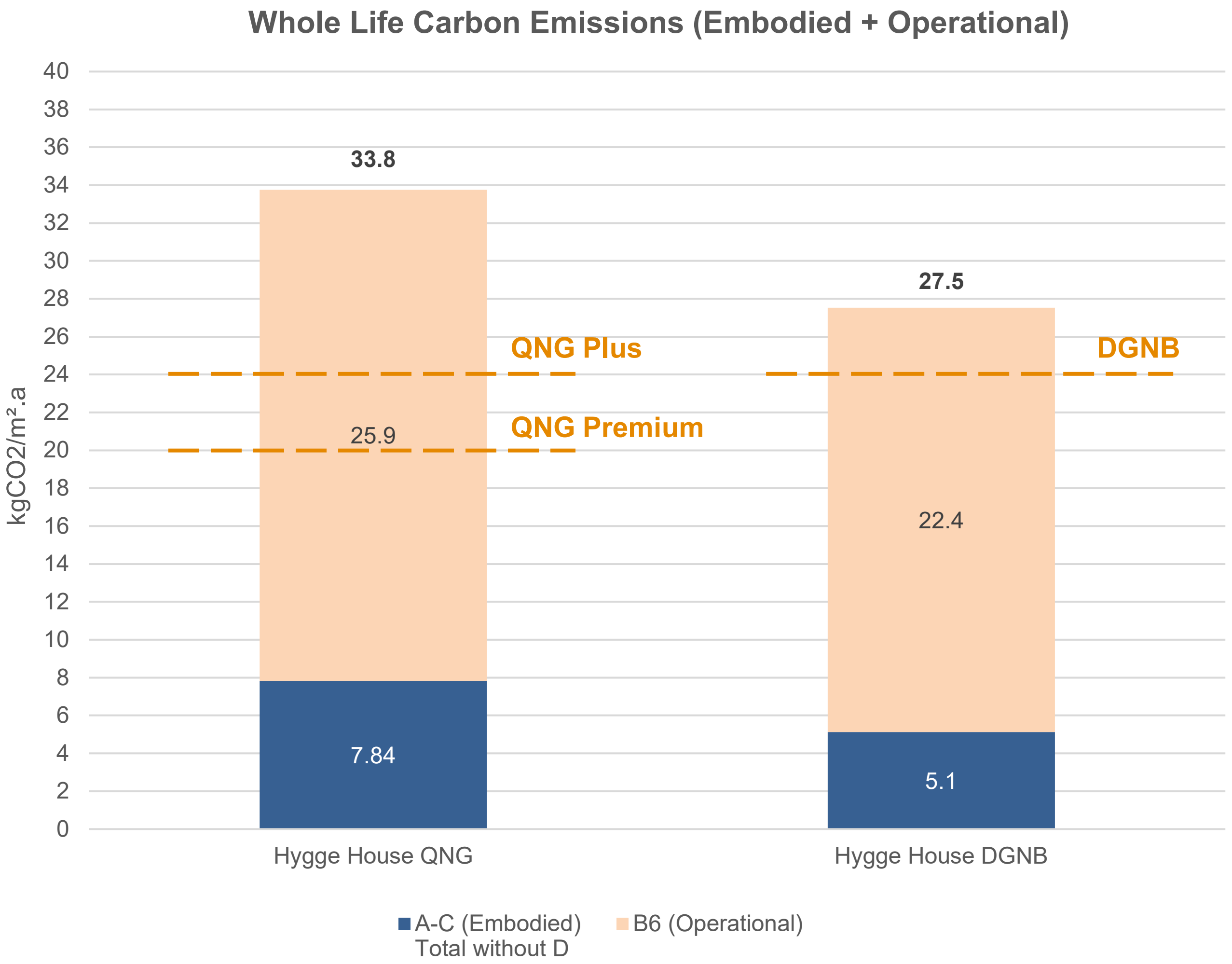
Hygge House | LCA

Whole Life Cycle Analysis

The Hygge house performs moderately well, staying above the reference values but relatively close to the limits.

Main differences between the two calculation methods are:

- The emission factors for the energy grid used in the calculation of the operational carbon are as follows:
  - DGNB Electricity Factor: according to Ökobau.dat 2023, **0.465 kgCO2/kWh**
  - QNG Electricity Factor: according to the QNG-Table **0.532 kgCO2/kWh**
- The EPD / carbon impact of the cellulose insulation; DGNB allows using the actual product specified made of recycled paper.
- The EPD / carbon impact of the PV system; the standard QNG value is higher compared to one selected in the DGNB analysis, much similar to the actual product selection.



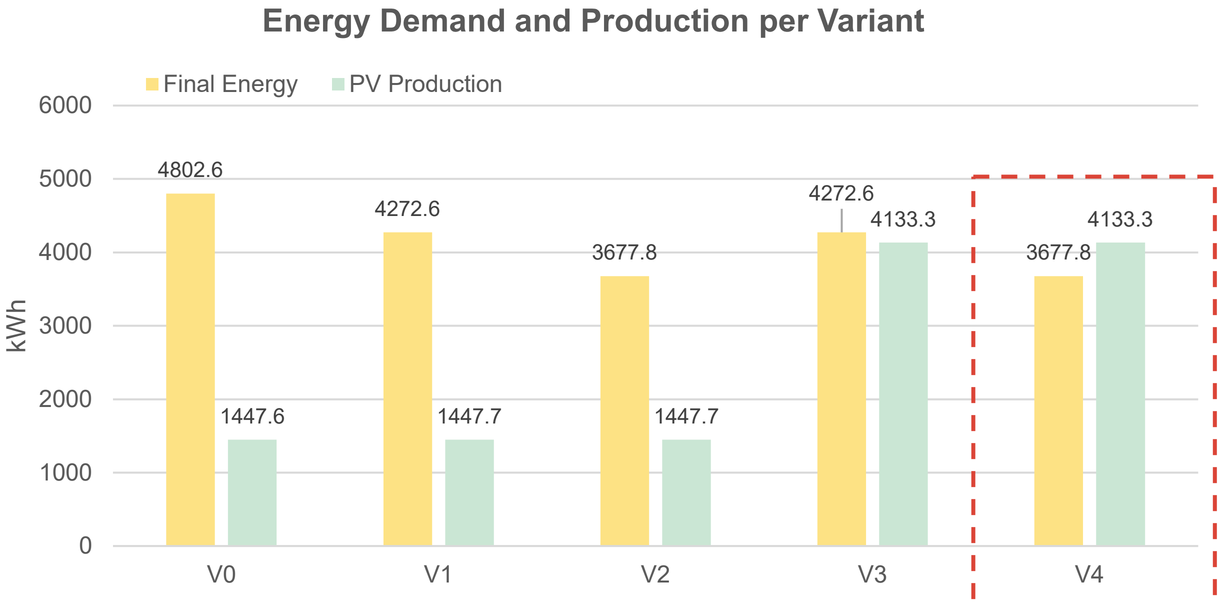
Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>
Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Hygge House | LCA

Operational carbon – Per Variant

To evaluate the effects of the various energy options in the building, the demand and production were compared side by side, as shown in the graph.

Variant 04 was chosen for the development of the LCA variant.



variant	V0	V1	V2	V3	V4
envelope	According to planing	According to BEG40	According to BEG40	According to BEG40	According to BEG40
ventilation	Natural ventilation	Natural ventilation	Mechanical ventilation	Natural ventilation	Mechanical ventilation
Photovoltaic	11 sqm of PV	11 sqm of PV	11 sqm of PV	11 sqm of PV + 20 sqm of PV	11 sqm of PV + 20 sqm of PV
Building Standard	Only GEG	Only envelope according to EH 40	EH 40	EH 40	EH 40

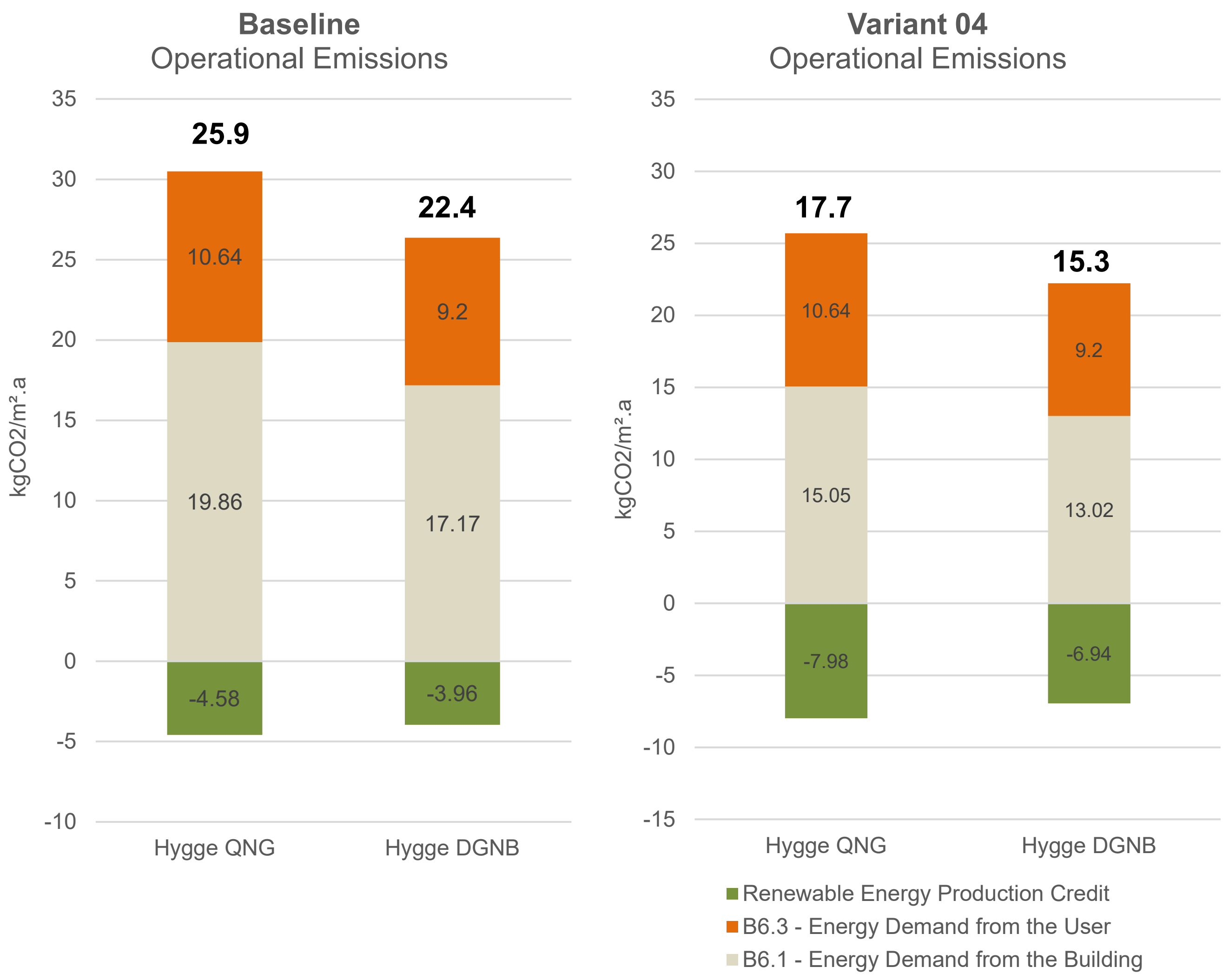
Hygge House | LCA

Operational carbon – Comparison Baseline and Variant 04

Increased PV production combined with reduced heating demand in the building, due to the heat exchange device, greatly affects the total emissions in Variant 04.

However, this effect does not extend to user demand, which is governed by standards and remains unaffected by the building's energy production.

Compared to the Baseline, there is an overall decrease of 29% in the QNG calculation and a 32% reduction in the DGNB calculation.

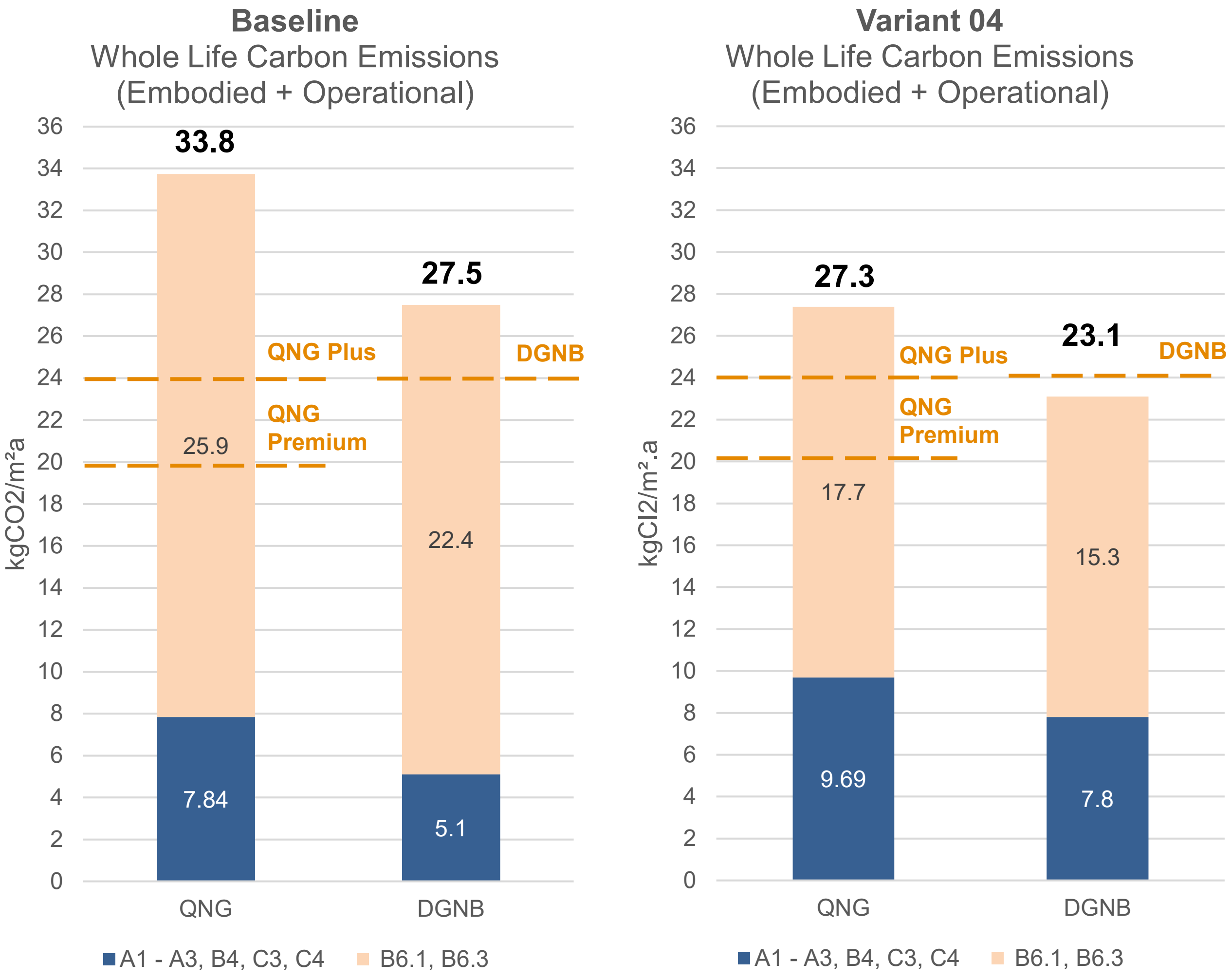


Hygge House | LCA

Operational carbon – Comparison Baseline and Variant 04

The effect of the added PV and heat exchange was also assessed in the embodied carbon analysis.

Overall, compared to the baseline, Variant 04 performs significantly better, successfully staying below the threshold set by the DGNB.



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

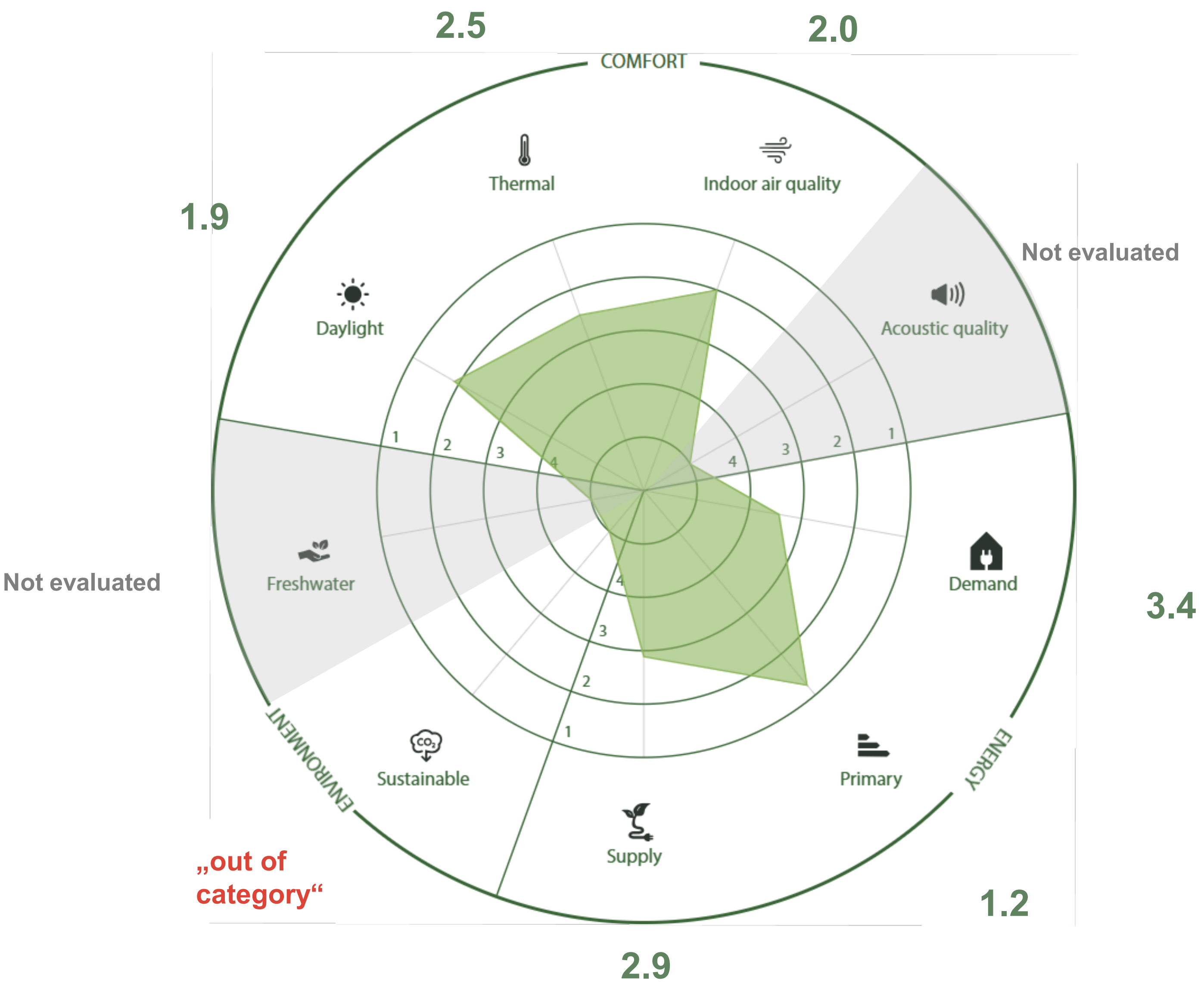
DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010

Active House Radar & conclusions

Active House Radar

Hygge House results



Transsolar Energietechnik GmbH
Stuttgart | München | Paris | New York
transsolar.com

DE +49 711 67976-0
US +1 212 219 2255
<transsolar(at)transsolar.com>

Transsolar Energietechnik GmbH | Curiestrasse 2 | 70563 Stuttgart | Germany
Transsolar Energietechnik GmbH | Balanstrasse 73, Haus 7 | 81541 Munich | Germany
Transsolar Inc. | 220 E. 23rd St. Suite 403 | New York, NY 10010