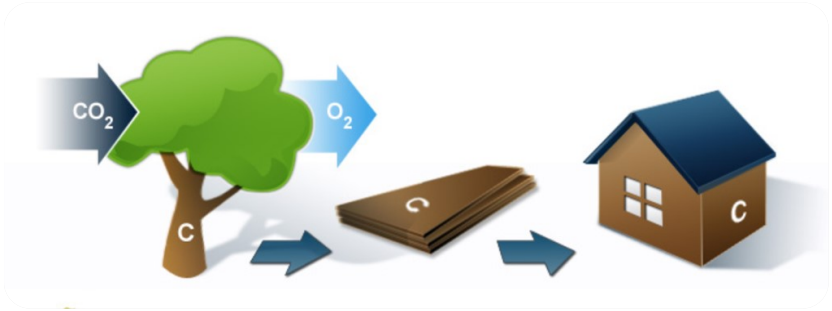



# Building with solid wood - Energy demand and climate protection

**LIF Project / Quality Association Log Buildings e. V.**

Josef Egle, Dipl.-Ing.

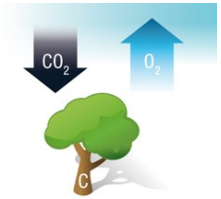
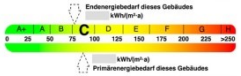
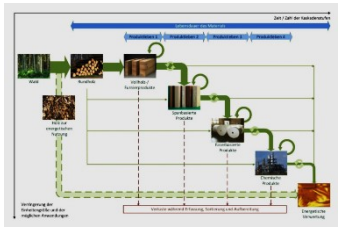
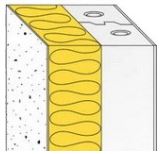
Publicly appointed and sworn expert for wooden houses, airthightness and building thermography

Approved inspection and certification body appointed by the DIBt (BAY34)

# Study 21-0201LIF

## Contents and targets

Proposal considering product/cascading effects

| | PRODUCT STAGE | USE STAGE | REUSE |
|---|---|---|---|
|  U = 0,496 W/(m²K) |   |   |  |
|  U = 0,281 W/(m²K) | | | |
|  U = 0,168 W/(m²K) | | | |
|  U = 0,136 W/(m²K) | ? |  | ? |

# Study 21-0201LIF

## Sources for calculations and comparisons

### Ecological indicators

Global Warming Potential (GWP)
Partially EPDs, partially databases oekobaudat.de and baubook.at;
hereof EN 15804:2020-03 modules A1-A3 („cradle to gate“), B1 (use)

### Heating requirements

End-energy demand according to Gebäudeenergiegesetz GEG for heating and warm water;
calculation with software ZUB HELENA ULTRA Version 7.111

### $CO_2$-emissions heating system

Emission factors Gebäudeenergiegesetz GEG Appendix 9 Table 3;
Air source heatpump, electricity 560 g $CO_{2,eq}$ / kWh, coefficient of performance (COP) 2,5

### Carbon capture and storage

EN 16449:2014-06, Spruce ρ = 460 kg/m³ with moisture content 12 %

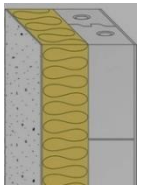
### Regarded building parts

Exterior and interior walls above cellar or basement with all layers, ceilings, roof with all layers, windows and external doors

# Study 21-0201LIF

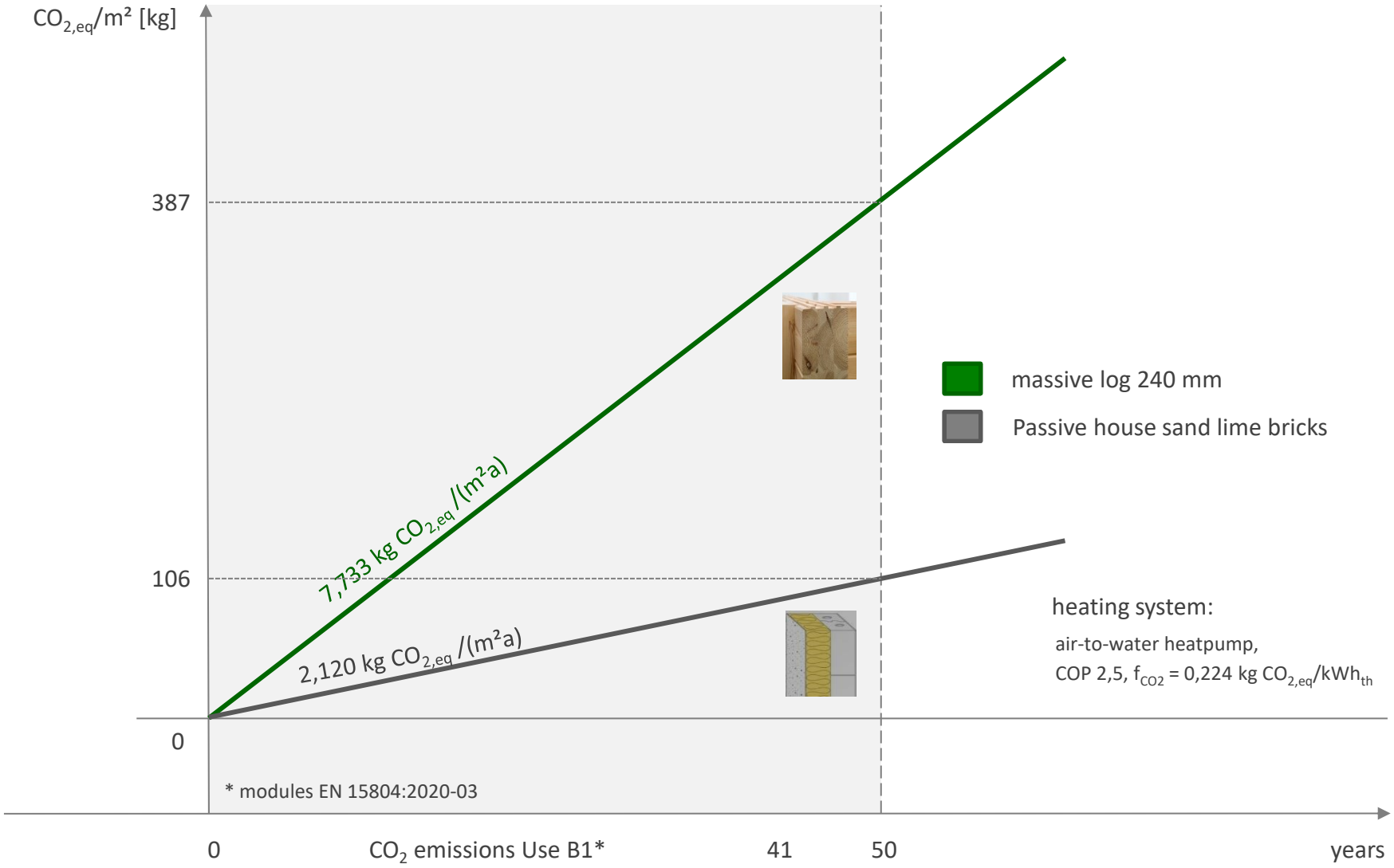
## Comparison type of construction relation exterior walls

**Relation: 1 m² exterior wall**

| Type of construction | heating energy demand heating system, degree days figure spez. $CO_2$ emissions | $CO_2$ emissions heating per year | GWP (A1-A3) exterior wall |
|---|---|---|---|
|  massive log 240 mm<br>U = 0,496 W/(m²K)<br>0,221 m³ wood / m² | 34,522 kWh/(m²a)<br>air-to-water heatpump<br>COP 2,5, 69,6 kKh/a<br>0,224 kg $CO_2$/kWh | 7.733<br>kg $CO_{2,eq}$/(m²a) | - 172,144<br>kg $CO_{2,eq}$ / m² |
|  Passivhouse standard<br>sand lime brick 175 mm<br>+ mineral wool 240 mm<br>U = 0,136 W/(m²K)<br>0,00 m³ wood / m² | 9,466 kWh/(m²a)<br>air-to-water heatpump<br>COP 2,5, 69,6 kKh/a<br>0,224 kg $CO_2$/kWh | 2,120<br>kg $CO_{2,eq}$/(m²a) | 56,870<br>kg $CO_{2,eq}$ / m² |

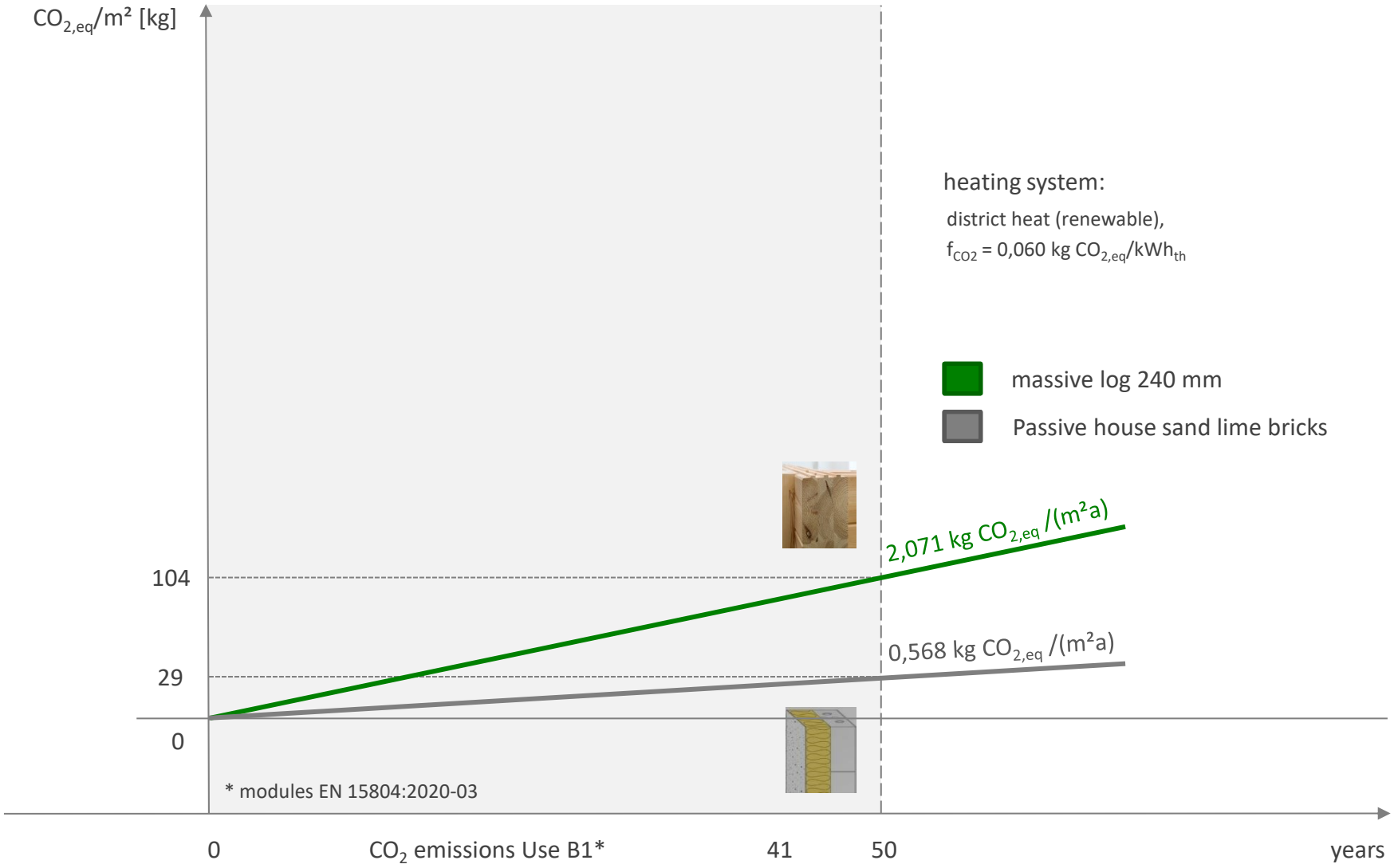
# Study 21-0201LIF

## Comparison type of construction relation exterior walls



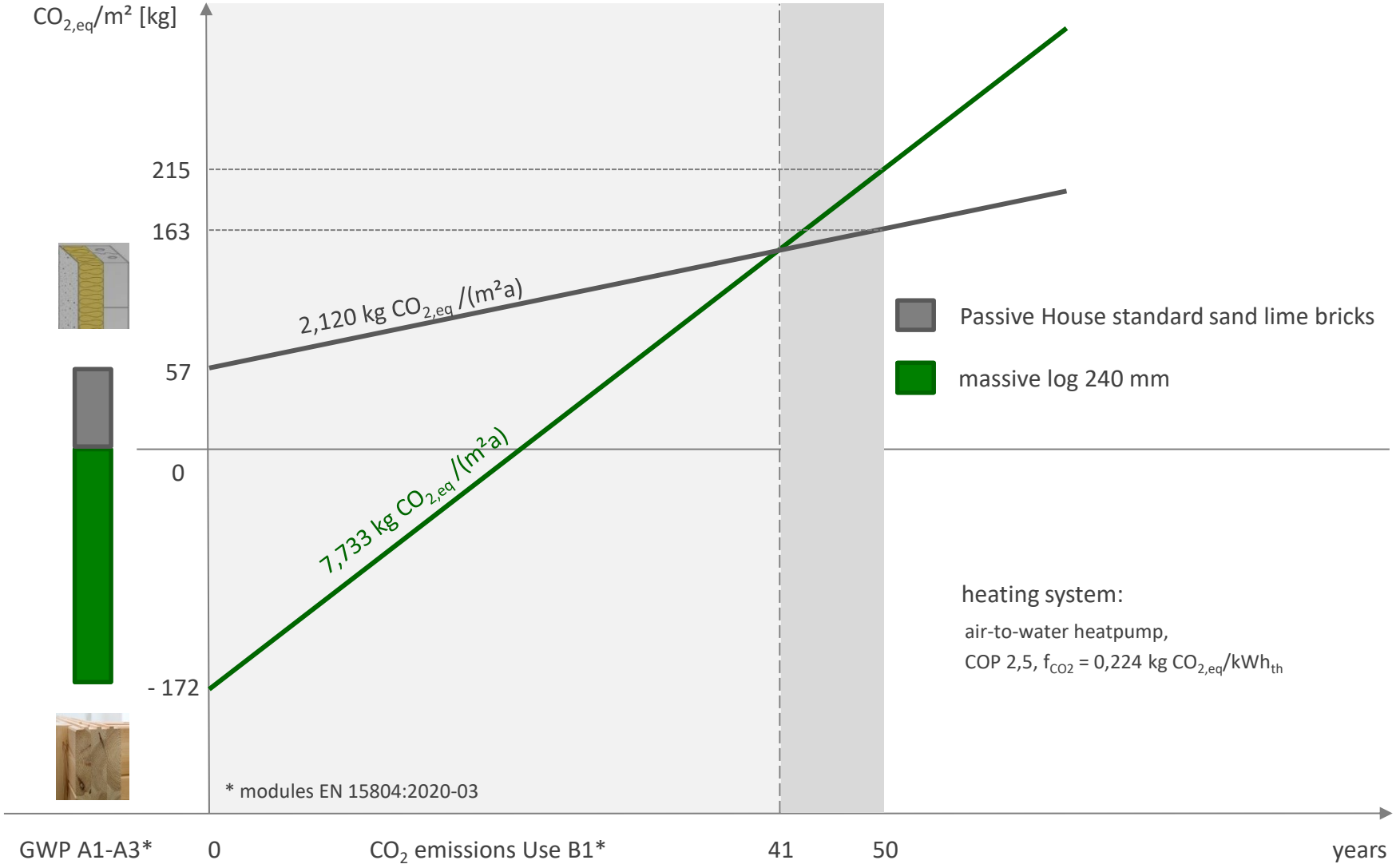
# Study 21-0201LIF

## Comparison type of construction relation exterior walls



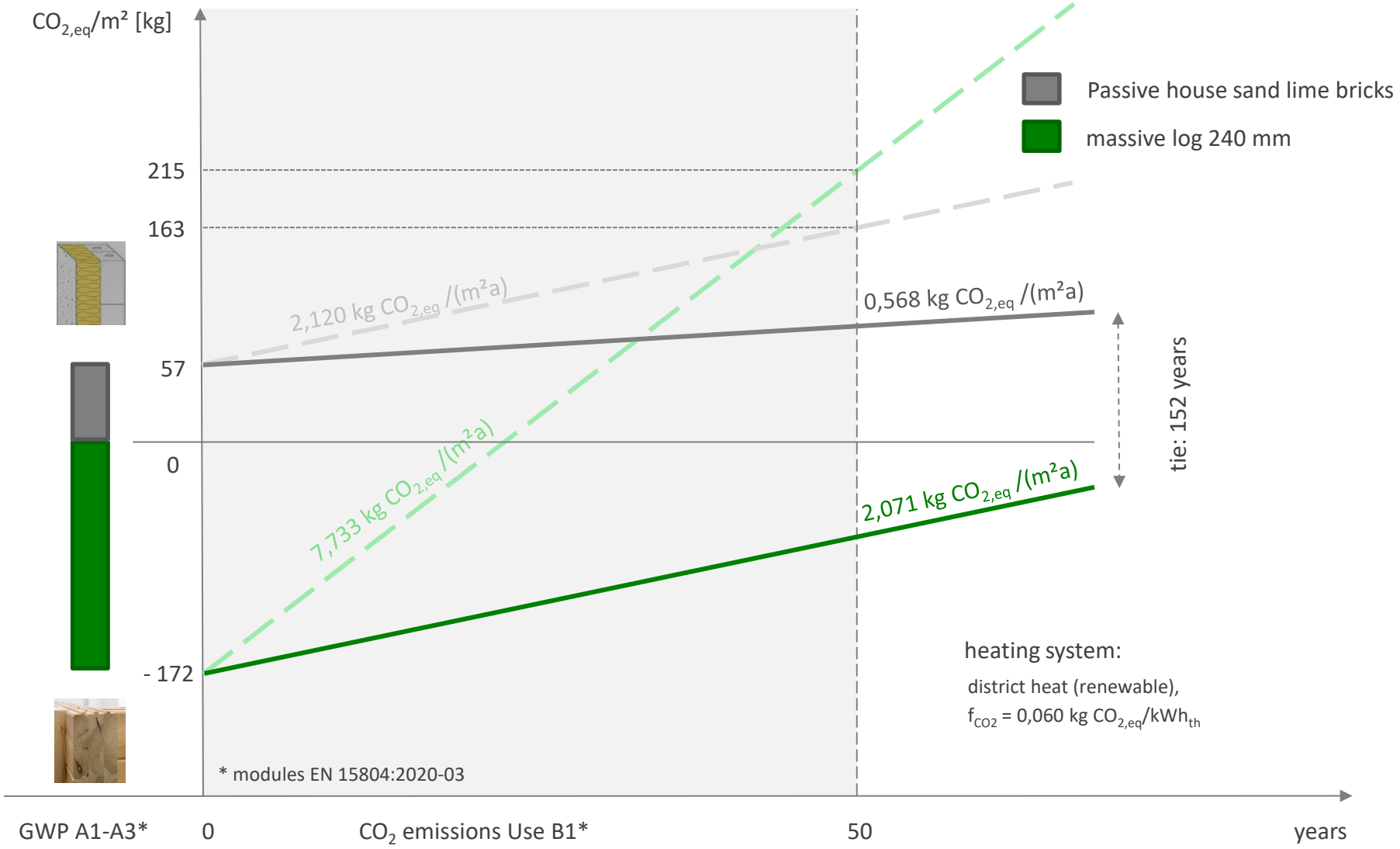
# Study 21-0201LIF

## Comparison type of construction relation exterior walls



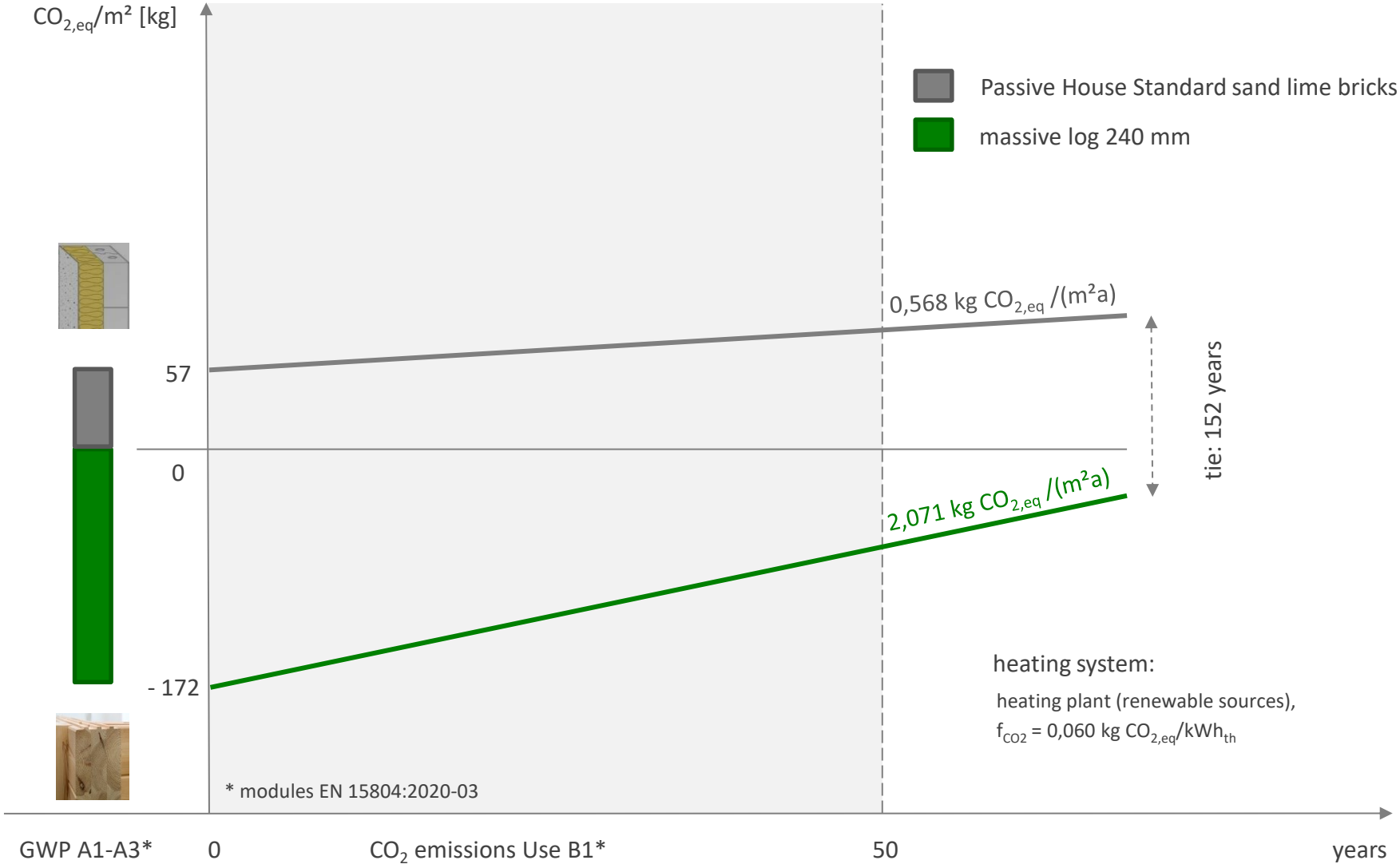
# Study 21-0201LIF

## Comparison type of construction relation exterior walls



# Study 21-0201LIF

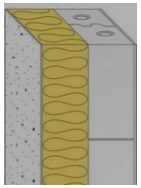
## Comparison type of construction relation exterior walls



# Study 21-0201LIF

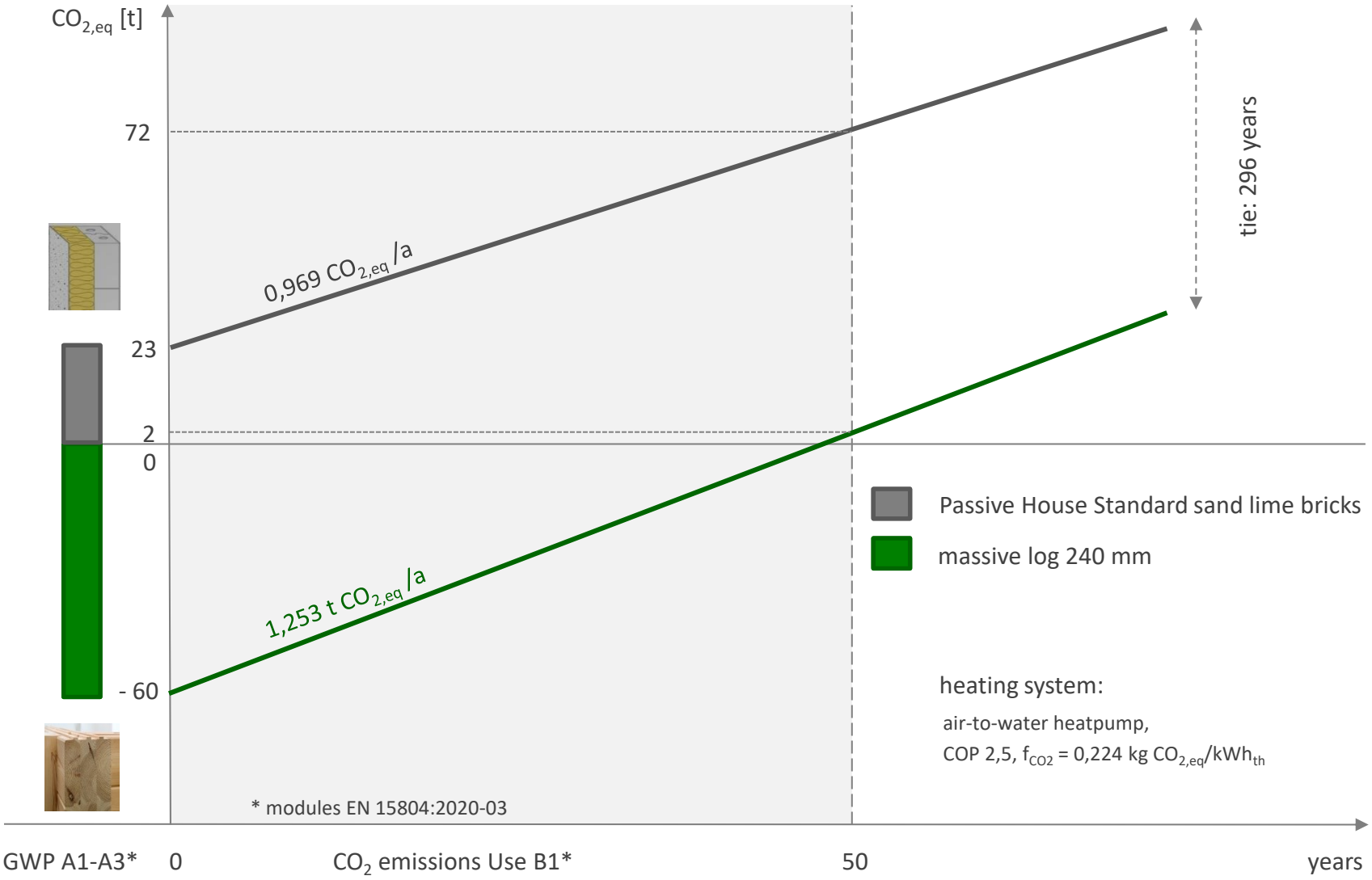
## Comparison type of construction relation building

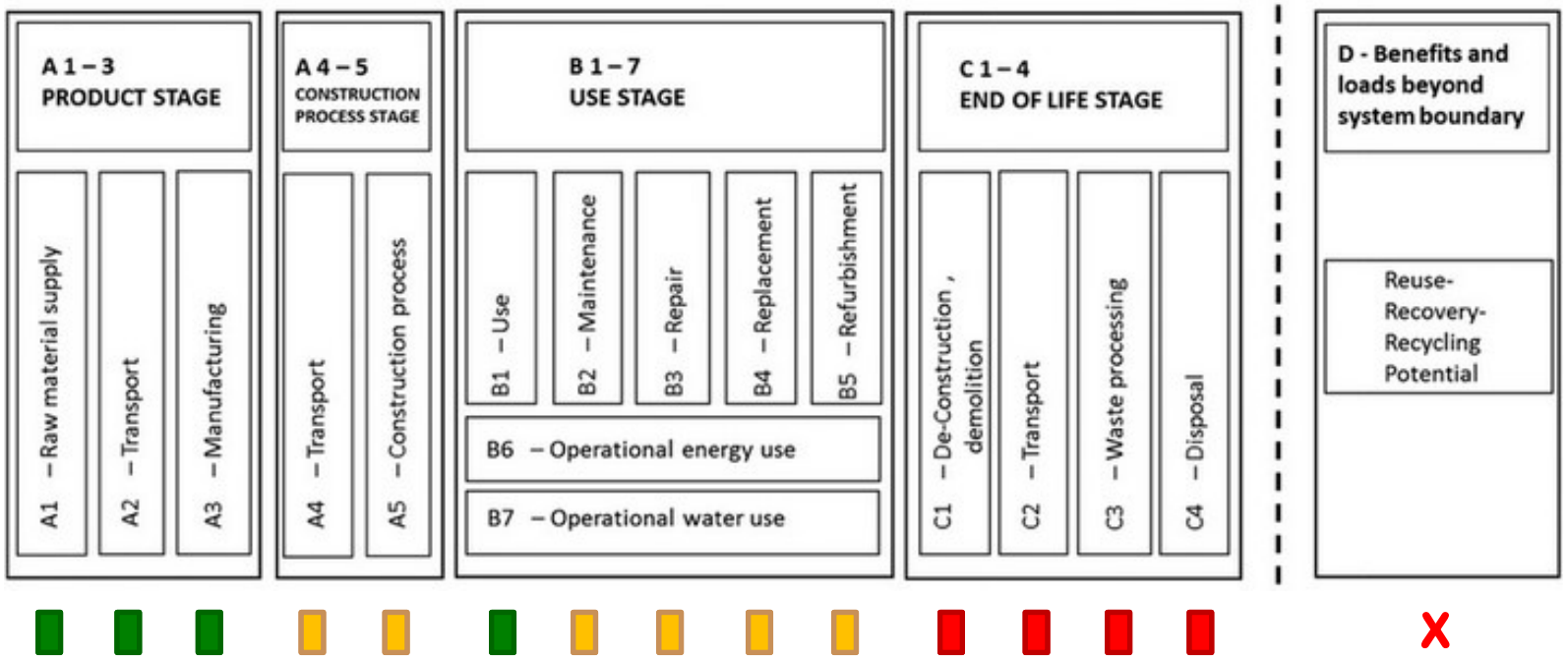
single family house 2 stores
ground area 8,80 m x 11,0 m
location A – 5542 Flachau

| type of construction | | heating energy demand heating system, degree days figure spez. $CO_2$ emissions | $CO_2$ emissions heating per year | GWP (A1-A3) building | carbon bond building |
|---|---|---|---|---|---|
|  | massive log 240 mm | 5.594 kWh/a<br>air-to-water heatpump<br>COP 2,5<br>0,224 kg $CO_2$/kWh | 1,253 t $CO_{2,eq}$/a | - 60 t $CO_{2,eq}$ | 205 t $CO_2$ |
|  | passive house standard sand lime bricks 175 mm + mineral wool 240 mm | 4.328 kWh/a<br>air-to-water heatpump<br>COP 2,5<br>0,224 kg $CO_2$/kWh | 0,969 t $CO_{2,eq}$/a | 23 t $CO_{2,eq}$ | 13 t $CO_2$ |

# Study 21-0201LIF

## Comparison type of construction relation building




large database, significant differences building parts and thermal standard

moderate database, low differences building parts und thermal standard

no usable data base at building time

### 28. End of life – building demolition, module C

| Table 28 End-of-life process description, sawn and planed timber | | |
|---|---|---|
| Process flow | Unit | Share of declared unit |
| Collection process specified by type | Collected separately | 97 % |
| | Collected with mixed construction waste | 3 % |
| Recovery system specified by type | Components for reuse | 0 |
| | Material for recycling | 0 |
| | Energy recovery | 97 % |
| Disposal specified by type | Loss (mixed waste) | 3 % |
| Assumptions for scenario development | Transportation distance to energy use 50 km, volume capacity utilization 50 %. | |

Finnish Sawmills Association

Issue date: 10.06.2021

Studiengemeinschaft Holzleimbau e.V.

Issue date: 03.09.2018

**Ende des Lebenswegs (C1-C4)**

| Bezeichnung | Wert | Einheit |
|---|---|---|
| Altholz zur Energierückgewinnung | 475,63 | kg |
| Redistributionsdistanz des Altholzes (Modul C2) | 20 | km |

Für das Szenario der thermischen Verwertung wird eine Sammelrate von 100 % ohne Verluste durch die Zerkleinerung des Materials angenommen.

**Wiederverwendungs- Rückgewinnungs- und Recyclingpotential (D), relevante Szenarioangaben**

| Bezeichnung | Wert | Einheit |
|---|---|---|
| Erzeugter Strom (je t atro Altholz) | 968,37 | kWh |
| Genutzte Abwärme (je t atro | 7053,19 | MJ |

7 Umwelt Produktdeklaration Studiengem
Konstruktionsv

Altholzverordnung – AltholzV

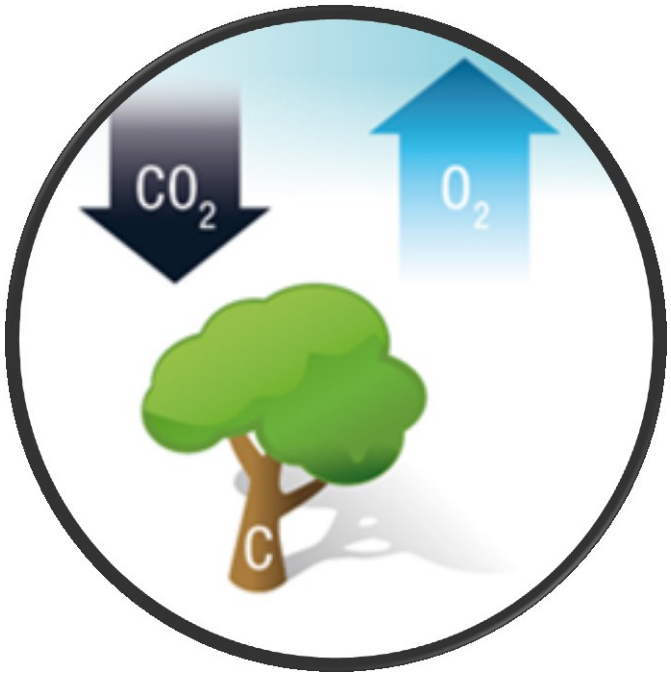
15. August 2002, last modification 19. Juni 2020

7. stoffliche Verwertung von Altholz:
   a) Aufbereitung von Altholz zu Holzhackschnitzeln und Holzspänen für die Herstellung von Holzwerkstoffen,
   b) Gewinnung von Synthesegas zur weiteren chemischen Nutzung und
   c) Herstellung von Aktivkohle/Industrieholzkohle;

8. energetische Verwertung von Altholz:
   Verwertung von Altholz im Sinne des § 3 Absatz 23 in Verbindung mit dem Verfahren R 1 der Anlage 2 des Kreislaufwirtschaftsgesetzes;

# Carbon capture and storage

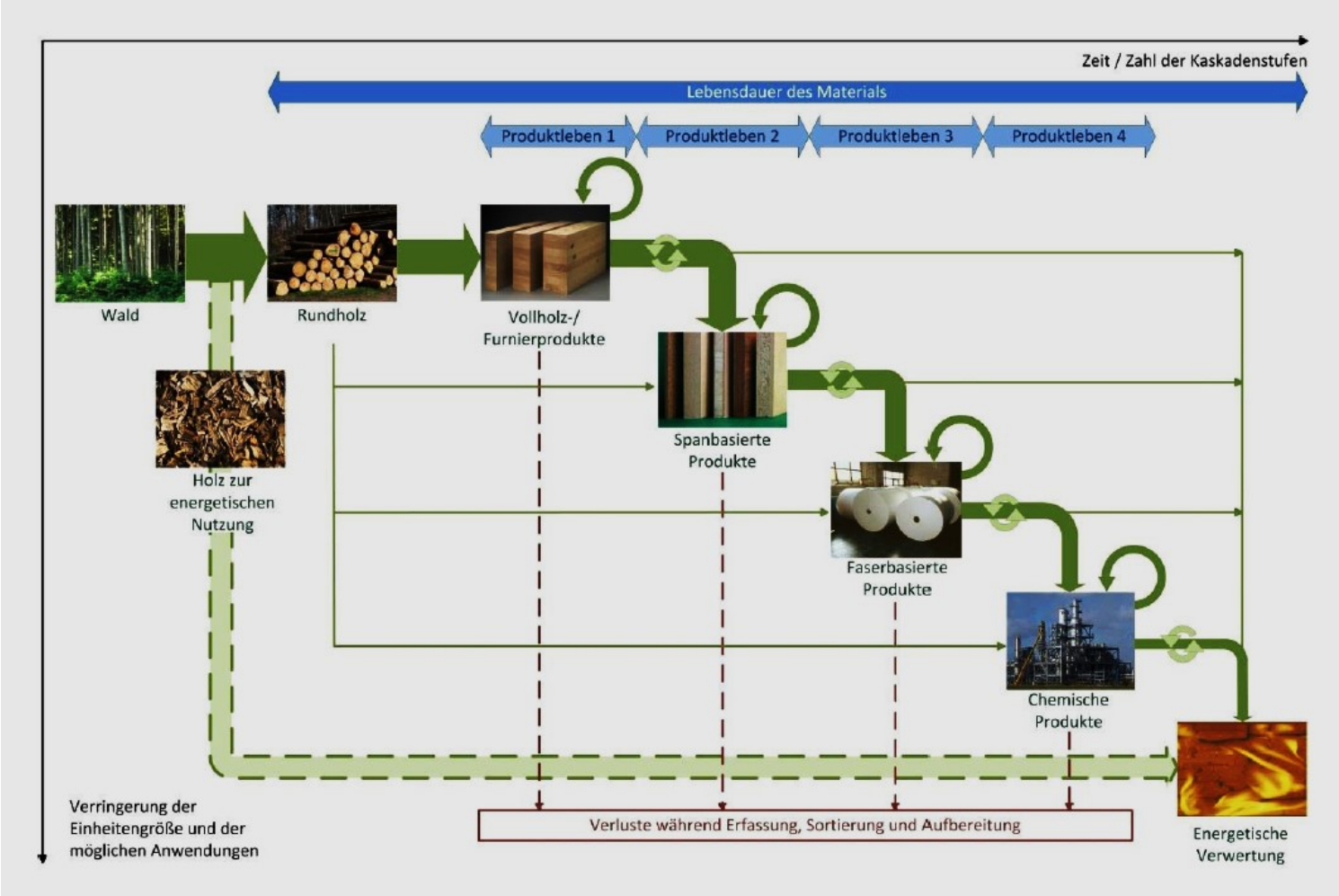
## molecular masses - „law of nature“




| | |
|---|---|
| oxygen [O] | 15,999 g/mol |
| carbon (fixed) [C] | 12,0107 g/mol |
| carbon dioxide[$CO_2$] | 44,0087 g/mol |
| wood growth: | 1 kg C ≈ 44/12 = 3,87 kg $CO_2$ |
| ratio C in wood: | 50 % |
| transformation: | 1 kg Holz = 1,83 kg $CO_2$ |
| spruce/fir: | 460 kg/m³ |
| content of water: | 12 % (by mass) |
| carbon storage: | 44/12 * 0,50 kg $CO_2$ / kg * 460 kg/m³ / 1,12 = 752,9 ≈ 753 kg $CO_2$ /m³ (EN 16449) |

# Untersuchung 21-0201LIF

## Cascade utilisation

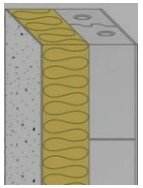



Source: TUM / Höglmeier et al.

# Offsetting carbon bond

## Basics

single family house 2 stores
ground area 8,80 m x 11,0 m
exterior walls 182,9 m²

| type of construction | carbon bond building | carbon bond exterior walls (182,9 m²) |
|---|---|---|
|  massive log 240 mm | 205 t $CO_2$ | 75 t $CO_2$ → reducement cascading factor → offsetting demands thermal protection |
|  Passive house standard sand lime bricks 175 mm + mineral wool 240 mm | 13 t $CO_2$ | - → no offsetting demands thermal protection |

# Offsetting carbon bond

## Specifications

***1.***

*The demands for thermal quality of the building envelope are allowed to be reduced to a certain extent, if there are renewable materials in the exterior walls.*

***2.***

*The possibility of structural reuse in the sense of cascading is to be regarded.*

***3.***

*All legal requirements to moisture proofing must be respected.*

***4.***

*Over a period of 50 years the $CO_2$ balance („carbon footprint“) from carbon bond and use stage must be equal or lower than with standard calculation (regarded only use stage).*

# Offsetting carbon bond

## Calculation formula

$$U_{mod,CO2} = U_{limit} + \Delta U_{CO2}$$

| | |
|---|---|
| $U_{mod,CO2}$: | modified U-value when using renewable building material [W/(m²K)] |
| $U_{limit}$: | permissible maximum U-value for new buildings [W/(m²K)] |
| $\Delta U_{CO2}$: | permissible enhancement U-value by renewable materials [W/(m²K)] |

$$\Delta U_{CO2} = C_{biogen} / (U * GTZ * f_{CO2}) / 50 \text{ years} * f_{cas} * f_{EW}$$

| | |
|---|---|
| $C_{biogen}$: | biogen bond [kg $CO_2$/m²] |
| $U_{EW}$: | standard U-value exterior wall [W/(m²K)] |
| GTZ: | degree days figure [kKh/a] |
| $f_{CO2}$: | $CO_2$ factor heating system [kg $CO_2$/$kWh_{thermisch}$] |
| $f_{CAS}$: | cascading factor [-] |
| $f_{EW}$: | area segment exterior walls according to $U_{limit}$ [%/100] |

# Offsetting carbon bond

## Example component procedure

single family home 2 stores

exterior walls 182,9 m²

cascading factor $f_{CAS}$:

low probability material reuse = 0,20

medium probability material reuse = 0,50

High probability material reuse = 0,80

| | |
|---|---|
| maximum U-value exterior walls: | $U_{limit} \leq 0{,}350$ W/(m²K) |
| Heating system: | air-water heatpump, $f_{CO2}$ = 0,224 kg $CO_2$/kWh |
| Carbon bond exterior wall: | $C_{biogen}$ = 166 kg $CO_2$/m² (1-schalige Außenwand 240 mm) |
| U-value exterior wall: | 0,496 W/(m²K) |
| GTZ: | 76 kKh/a (region Salzburg) |
| Utilisation phase: | 50 years |
| cascading factor $f_{CAS}$ : | 0,50 |

$\Delta U_{CO2} = C_{biogen} / (U * GTZ * f_{CO2}) / 50\ a * f_{cas} * f_{EW}$

$\Delta U_{CO2}$ = 166 kg $CO_2$/m² / (0,496 W/(m²K) *76 kKh/a * 0,224 kg $CO_2$/kWh) / 50 a *0,50 * 1,00

$\Delta U_{CO2}$ = 0,197 W/(m²K)

$U_{mod,CO2} = U_{limit} + \Delta U_{CO2}$

$U_{mod,CO2}$ = 0,35 W/(m²K) + 0,197 W/(m²K) = 0,547 W/(m²K)

**$U_{EW}$ (0,496 W/(m²K) < $U_{mod,cO2}$ (0,547 W/(m²K) -> condition is satisfied**

# EAD – European Assessment Document

The Basic Works Requirements (or 'BWR' for short) are described in Annex I of the Construction Products Regulation. The Construction Products Regulation distinguishes seven basic requirements:

- mechanical resistance and stability (BWR 1),
- safety in case of fire (BWR 2),
- hygiene, health and the environment (BWR 3),
- safety and accessibility in use (BWR 4),
- protection against noise (BWR 5),
- energy economy and heat retention (BWR 6) and
- sustainable use of natural resources (BWR 7).

These basic requirements result from the building provisions of the Member States.

Source: DIBt

# EAD

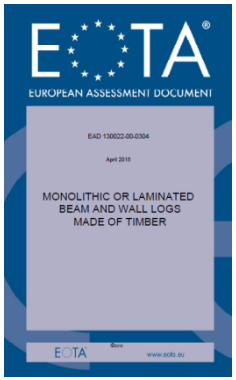
## Existing documents log construction

BWR 7 – sustainable use of natural resources


## EAD 340308-00-0203

Timber Building Kits

no information




## EAD 13022-00-0304

Monlithic or laminated beam and wall logs made of timber

no information