## Construction set

To properly analysis the envelope of the building, materials have been composed in the energy models according to the detail drawings by LINK Arkitektur.

The first to be analysed, was an external wall.

A blueprint of a beam

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Figure 5. Fragment of Drawing A-D-23-1-6-05 by LINK Arkitektur

Parameters required for the energy model are thickness, conductivity, density and specific heat of the material. Those values have been based on an available documentation about the building, but also software Ubakus (‘Ubakus’, 2025) and verified with the product description.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **External wall - ZEB YV-223+73\_Trepanel/G** | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| ~~Vertical panel double bevel square edge~~ | ~~0.019~~ | ~~0.13~~ | 500 | 1600 |
| ~~Horizontal batten~~ | ~~0.068~~ | ~~0.12~~ | 450 | 1600 |
| ~~Vertical batten~~ | ~~0.036~~ | ~~0.12~~ | 450 | 1600 |
| ~~Wind barrier fabric, black~~ | ~~0.002~~ | ~~0.04~~ | 60 | 1400 |
| GU-x | 0.09 | 0.22 | 1000 | 1000 |
| Frame with mineral wool | 0.223 | 0.046 | 74 | 1900 |
| Vapor barrier | 0.005 | 0.22 | 130 | 1700 |
| Inner furring with mineral wool | 0.073 | 0.046 | 74 | 1900 |
| Gypsum board | 0.013 | 0.25 | 680 | 960 |

Table 4. External wall - ZEB YV-223+73\_Trepanel/G construction

According to the Building Energy Performance document (‘418722-RIBfy-NOT-002 Bygningsmessige energiytelser’, 2019), the U-value of the wall is calculated to be 0.15 W/m2K, although according to GH calculations after applying all the layers from Table 4, it was 0.12 W/m2K, which may be caused by unproper construction of the horizontal and vertical battens in the software, since that layer in most of its volume consist of air, which is not accounted for by the simulation. Due to that factor, and since in the Energy Report it stands that the wall U-value was also 0.15 W/m2K, the external layers after GU-x have been omitted to simplify material construction and match the component U-value of 0.15 W/m2K. maybe don’t write about those battens but just delete those layers saying they are not significant? idk

According to drawing A-D-23-1-6-15, there is also Another type of external wall:

A blueprint of a building

AI-generated content may be incorrect.

Figure 6. Fragment of Drawing A-D-23-1-6-15 by LINK Arkitektur

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **External wall - ZEB YV-223 120M Solceller** | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| BIPV |  |  |  |  |
| Solar panel mounting |  |  |  |  |
| Vertical batten | 0.036 | 0.12 | 450 | 1600 |
| Wind barrier fabric, black | 0.002 | 0.04 | 60 | 1400 |
| GU-x | 0.09 | 0.22 | 1000 | 1000 |
| Frame with mineral wool | 0.223 | 0.046 | 74 | 1900 |
| Vapor barrier | 0.005 | 0.22 | 130 | 1700 |
| Solid wood (CLT) | 0.12 | 0.13 | 471 | 1600 |

Table 5. External wall - ZEB YV-223 120M Solceller construction

According to the Building Energy Performance document, the U-value of the wall is calculated to be 0.16 W/m2K and the average U-value for simulation was chosen as 0.15 W/m2K according to the Energy Report. Meanwhile, according to the Table 5, U-value equals 0,14 W/m2K without accounting for the BIPV which may be very hot). The same as with the first type of wall, the external layers on the top of GU-x layer have been omitted in the simulation model to simplify material construction and match the value from the Energy Report.

Both walls have the same U-value, so there is no need to include them both in the simulation model. Therefore, the first type was chosen as the external wall for simulations.

Next to be analysed, was roof construction.

A blueprint of a roof

AI-generated content may be incorrect.

Figure 7. Fragment of Drawing A-D-23-4-6-05 by LINK Arkitektur

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Roof** | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| BIPV |  |  |  |  |
| Solar panel mounting |  |  |  |  |
| Vertical batten | 0.048 | 0.12 | 450 | 1600 |
| Beams and Rockwool | 0.4 | 0.046 | 81 | 900 |
| Vapour barrier | 0.005 | 0.22 | 130 | 1700 |
| Battens | 0.023 | 0.12 | 450 | 1600 |
| Gypsum board | 0.013 | 0.25 | 680 | 960 |

Table 6. External roof construction

On the other hand, the roof U-value from calculations (0,1 W/m2K) turned out to be higher than the one from documentation, which equals 0,09 W/m2K. That may be reasoned by omitting the external layers of BIPV panels and their mounting in the simulation model. To match the values with the ones from Energy Report, the value of 0.1 W/m2K was achieved by adjusting the insulation thickness.

Floor

A close-up of a blueprint

AI-generated content may be incorrect.

Figure 8. Fragment of drawing A-D-23-1-6-03 by LINK Arkitektur

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Floor on the ground** | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| Reinforced concrete | 0.1 | 2.3 | 2300 | 880 |
| PE foil | 0.2 | 0.4 | 930 | 1800 |
| EPS/XPS | 0.25 | 0.037 | 20 | 1500 |
| Radon barrier | 0.2 | 0.33 | 950 | 1900 |

Table 7. Floor on the ground construction

Result from implementing the values from the Table 7 in Grasshopper simulation model gives a U-value of 0.12 W/m2K, but according to the Energy Report, the floor's equivalent U-value is calculated to be 0.1 W/m²K, which already accounts for the heat loss factor and heat contribution from the ground. Again, to match the energy report’s U-value, XPS thickness have been risen as much as required to fit the 0.1 W/m2K U-value and has been modelled as exposed floor, not floor on the ground. Technically this should be accurate, while applying an equivalent U-value, but while running the simulation with the same material set and testing both exposed floor and floor on the ground + average monthly ground temperature list, heating load value was 20% higher for floor on the ground.

Windows size and placement was based on elevation drawings by LINK Arkitektur and their parameters (U-value and total solar factor) adjusted accordingly to the Energy Report. All the windows have a U-value of 0.77 W/m²K, but their solar factor differ. Northen window: 0.45, southern except the ones behind solar cells: 0.1, than southern behind cells and all the remaining ones: 0.35.

The louvers on the northern façade were added based on the Revit model. Transmittance was set as 0.6 value for all of the windows, which was based on windows specification documentation.

Internal mass

In the Simien model, a normalized heat capacity of 81 Wh/m²K was added for the core and sole in solid wood. To account for this in the Grasshopper energy model, it was added as internal mass in the single-zone model, and as geometry in the multi-zone model. Additionally, mass representing staircases was also included.

For consistency between the single-zone and multi-zone models, the slab and interior wall areas were adjusted in line with the multi-zone setup, since these structures are automatically treated as internal mass when used as zone-dividing elements.

Because internal mass is interpreted by the software as a surface area, each surface must either be split in half and modelled on both sides, or, if the material is identical on both sides, the area of one half should be modelled and multiplied by two.

Internal slab

From drawing A-D-23-2-6-15

A diagram of a mattress

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Figure 9. Fragment of Drawing A-D-23-2-6-15

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Internal slab | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| Chipboard | 0.044 | 0.14 | 650 | 1800 |
| Mineral wool | 0.068 | 0.035 | 20 | 830 |
| CLT | 0.21 | 0.13 | 471 | 1600 |

Table 8. Internal slab construction

There are a few types of internal walls, but since it’s only possible to model a symmetrical internal structure and don’t cause errors in a Grasshopper simulation, for all the walls the following interior wall construction has been applied.

From drawing A-D-23-2-6-04 by LINK:

A black and white drawing of a fence

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Figure 10. Fragment of Drawing A-D-23-2-6-04 by LINK Arkitektur

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Internal wall | | | | |
| Material | Thickness [m] | Conductivity [W/m-K] | Density [kg/m3] | Specific heat [J/kg-K] |
| Gypsum board | 0.026 | 0.25 | 680 | 960 |
| Wooden frame and mineral wool | 0.098 | 0.046 | 74 | 1900 |
| Gypsum board | 0.026 | 0.25 | 680 | 960 |

Table 9. Internal wall construction

## Thermal bridge

The heat loss through thermal bridges was accounted in original building simulations according to the Energy Report as a normalized thermal bridge factor, equal to 0,04 W/m2K. To account for it in GH simulation model, it has been added to the U-values of external walls and roof, by lowering the thickness of its insulation layers.