PASSIV
HAUS
INSTITUT

Dr. Wolfgang Feist

Heat bridge calculation to determine the point heat bridge loss coefficients of

system equipment carriers

Brief expert report

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on behalf of the company

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Introduction

On behalf of the company Kaiser GmbH & Co. KG, the Passivhaus Institut determined the heat bridge loss coefficients for two different types of system equipment carriers in an external wall (20 to 25 cm insulation). The following report documents the results of the heat flow simulation. The modelling is based on the documents provided by the client. The calculation includes the heat flow simulation of two adapters with different insulation thicknesses. Variants with modified heat conductivity of the insulation layer were also considered.

The calculations were carried out using the three-dimensional heat flow programme SOLIDO (version 2.0w) from Physibel, Belgium. This brief expert report documents the results.

Due to the possibility of dispensing with a separate heating system, passive houses place high demands on the quality of the components used. In addition to excellent heat insulation, high air tightness, highly efficient heat recovery and passive house windows, the absence of heat bridges in the thermal envelope is of outstanding importance for the function of the passive house.

Specifications for heat bridge calculation

Table 1 lists the materials used in the calculation and their heat conductivities in conjunction with the colours selected for the representation. Sources for the heat conductivities are laboratory measured values corrected to calculated values or relevant standards.

Table 1 Assignment of colours and heat conductivities to the materials used

Colour	λ W/mK	Designation
		Insulation
	0.025 - 0.040	Heat-insulation 025 - 040
	0.031	Neopor
		Plastic
	0.42	PE-HD
	0.25	Sealing plug
	0.30	Polyamide (PA)
		Mineral materials
	0.51	Interior plaster / plasterboard
	0.70	Exterior plaster
	1.0	Lime sand brick
		free materials
	6.97	Conduit replacement material

Boundary conditions

The selected boundary conditions are shown in Table 2.

Table 2 Heat transfer coefficients on the outer and inner surfaces

Boundary conditions	
Outside air temperature [°C]	-10.0
External heat transfer [W/(m^{2}K)]	25.0
Indoor air temperature [°C]	20.0
Heat transfer inside [W/(m^{2}K)]	7.7

Modelling

True-to-original 3D CAD models were modelled, consisting of interior plaster, sand-lime brick, thermal insulation and exterior plaster, as well as the respective system equipment carrier. Equivalent heat conductivities were calculated for the cable ducts, representing the plastic sheathing, a 3 x 1.5 mm^2 NYM cable and the air in the duct.

For the three-dimensional heat flow calculation, the models were divided into finite elements using a three-dimensional mesh. In the area of the system equipment carrier, the mesh size is smaller than 0.5 mm. The mesh size increases towards the edges of the model.

The system equipment carrier was inserted into these models to determine the respective heat bridge loss coefficients and the calculation was repeated. The difference between the undisturbed model and the model with adapter results in the heat bridge loss coefficient.

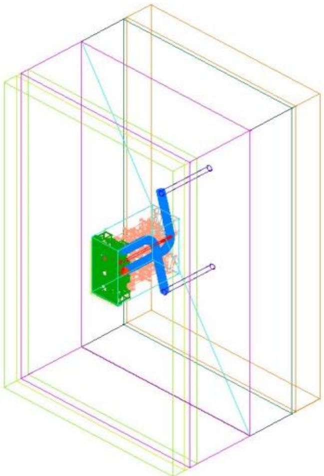

Fig. 1: Exemplary three-dimensional representation of the model

Model dimensions

Height	1,200 mm
Depth	560-610 mm
Width	700 mm

Wall construction (U= 0.19 to 0.10 W/(m^2K))

External plaster	20 mm
Insulation	200-250 mm
Sand-lime brick	175 mm
Interior plaster	15 mm

The standard heat transfer coefficients are listed below:

	Insulation thickness [mm]		
WLG	**200**	**250**	
040	0.1852	0.1503	[W/m^2K]
035	0.1635	0.1325	[W/m^2K]
032	0.1503	0.1217	[W/m^2K]
030	0.1415	0.1145	[W/m^2K]
029	0.1370	0.1108	[W/m^2K]
025	0.1190	0.0961	[W/m^2K]

The results of the heat flow calculations are listed below:

Insulation thickness [mm]	200	250
Insulation WLG	040	040
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	4.66644	3.78845
$Q_{Solido, WB}$ [W]	4.85622	3.96403
$T_{min, WB}$ [°C]	19.19	19.33
U_{Wall} [W/(m²K)]	0.1852	0.1503
Ueq WB	0.1927	0.1573
χ_{WB} [W/K]	0.00633	0.00585

Table 3: Results of the heat flow simulation (WLG 040)

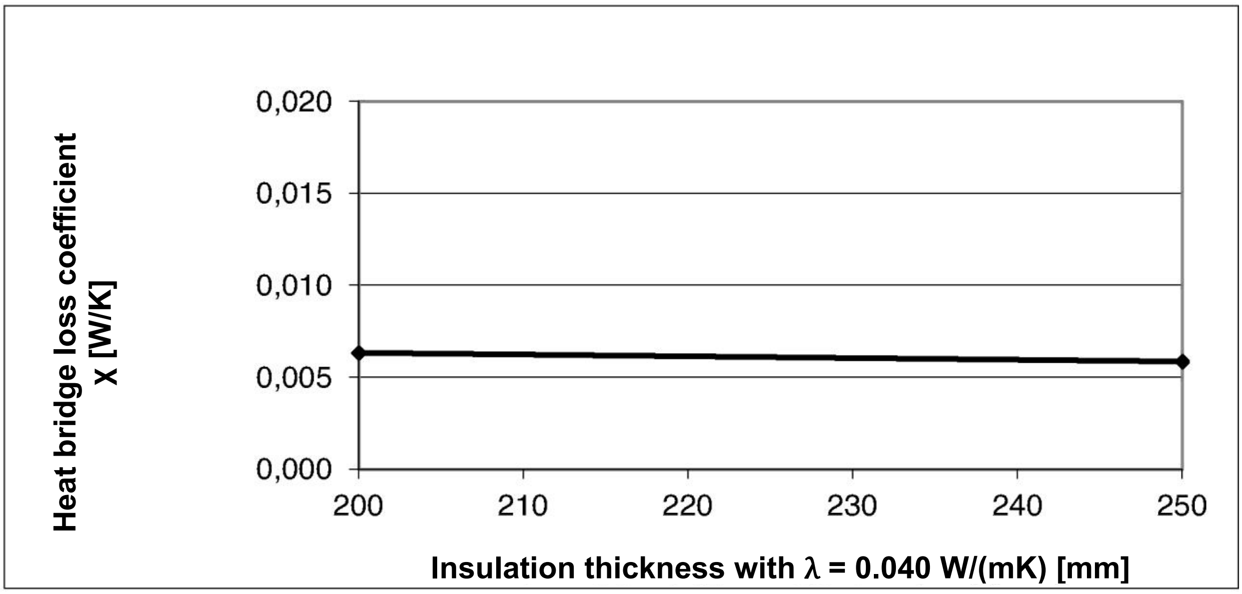

Fig. 2: Visualisation of the heat bridge loss coefficients (WLG 040)

Insulation thickness [mm]	200	250
Insulation WLG	035	035
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	4.12136	3.34012
$Q_{Solido, WB}$ [W]	4.32546	3.52925
$T_{min, WB}$ [°C]	19.27	19.39
U_{Wall} [W/(m²K)]	0.1635	0.1325
Ueq WB	0.1716	0.1400
χ_{WB} [W/K]	**0.00680**	**0.00630**

Table 4: Results of the heat flow simulation (WLG 035)

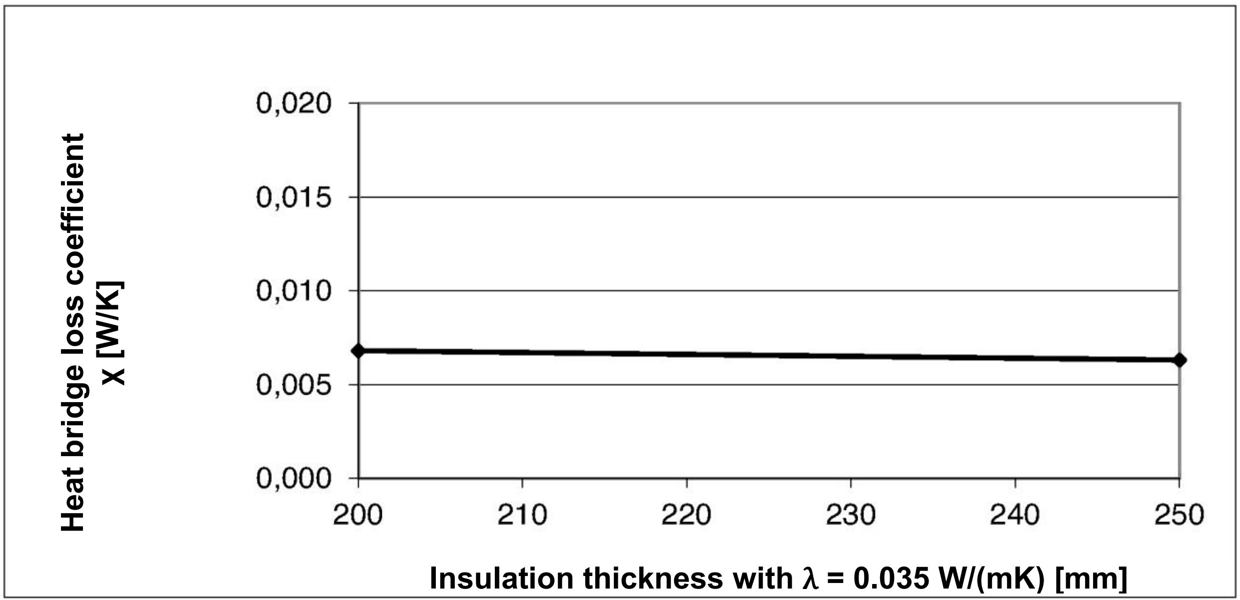

Fig. 3: Visualisation of the heat bridge loss coefficients (WLG 035)

Insulation thickness [mm]	200	250
Insulation WLG	032	032
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	3.78851	3.06766
$Q_{Solido, WB}$ [W]	4.00188	3.26517
$T_{min, WB}$ [°C]	19.32	19.43
U_{Wall} [W/(m²K)]	0.1503	0.1217
Ueq WB	0.1588	0.1296
χ_{WB} [W/K]	**0.00711**	**0.00658**

Table 5: Results of the heat flow simulation (WLG 032)

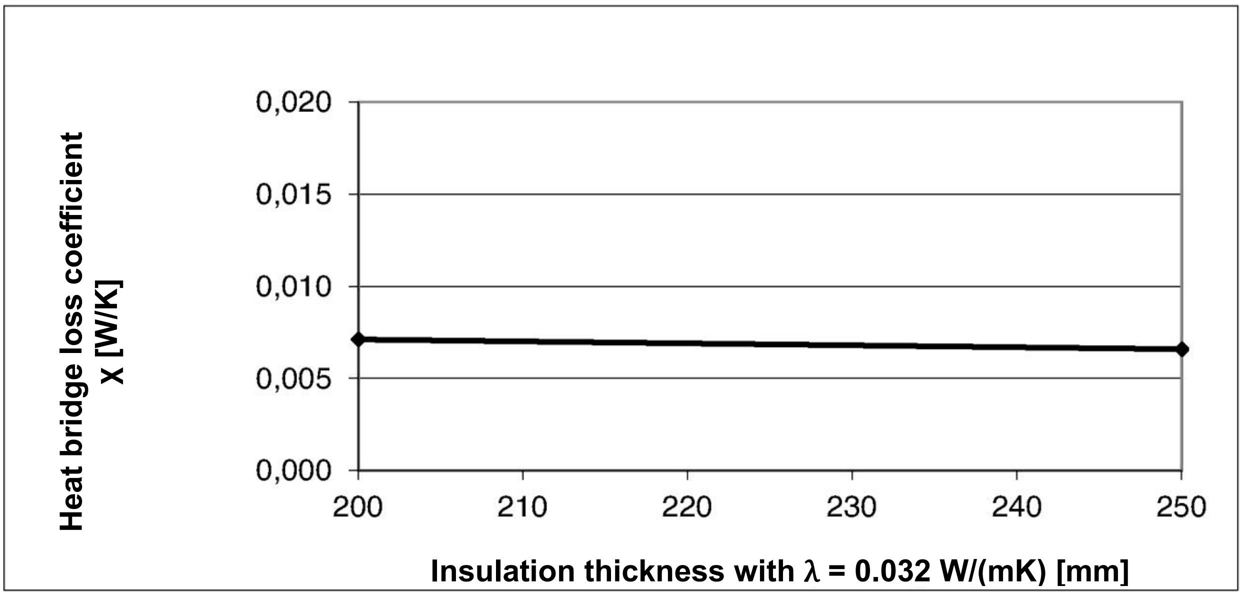

Fig. 4: Visualisation of the heat bridge loss coefficients (WLG 032)

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Insulation thickness [mm]	200	250
Insulation WLG	030	030
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	3.56540	2.88500
$Q_{Solido, WB}$ [W]	3.78401	3.08784
$T_{min, WB}$ [°C]	19.35	19.45
U_{Wall} [W/(m²K)]	0.1415	0.1145
Ueq WB	0.1502	0.1225
χ_{WB} [W/K]	**0.00729**	**0.00676**

Table 6: Results of the heat flow simulation (WLG 030)

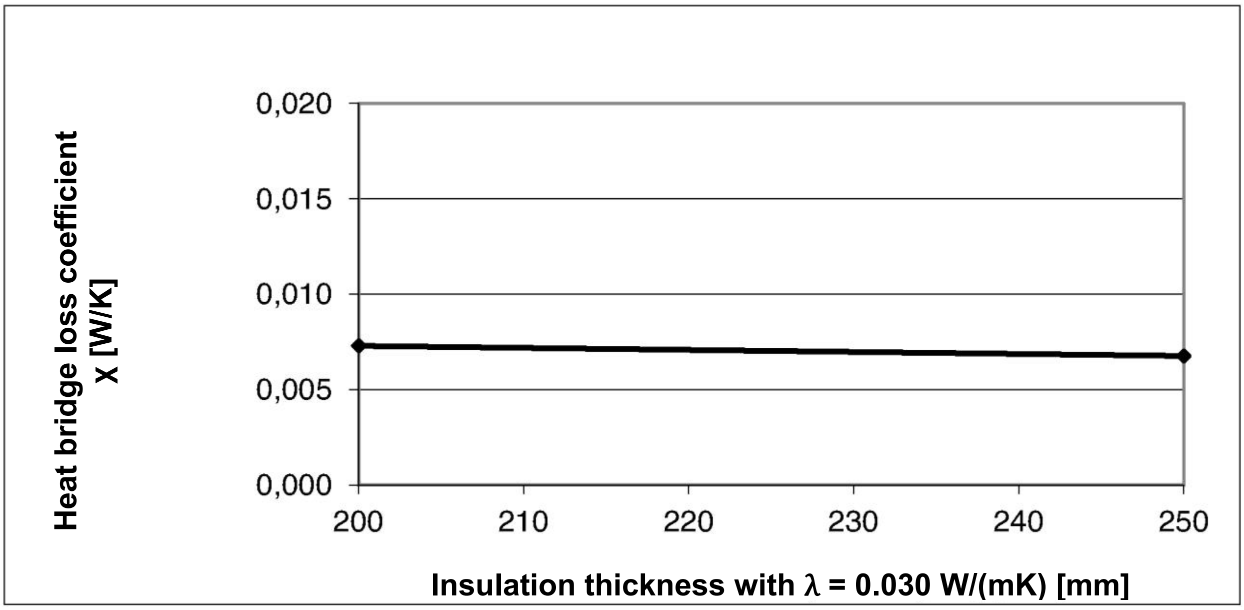

Fig. 5: Visualisation of the heat bridge loss coefficients (WLG 030)

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Insulation thickness [mm]	200	250
Insulation WLG	029	029
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	3.45276	2.79338
$Q_{Solido, WB}$ [W]	3.67444	2.99872
$T_{min, WB}$ [°C]	19.37	19.47
U_{Wall} [W/(m²K)]	0.1370	0.1108
Ueq WB	0.1458	0.1190
χ_{WB} [W/K]	**0.00739**	**0.00684**

Table 7: Results of the heat flow simulation (WLG 029)

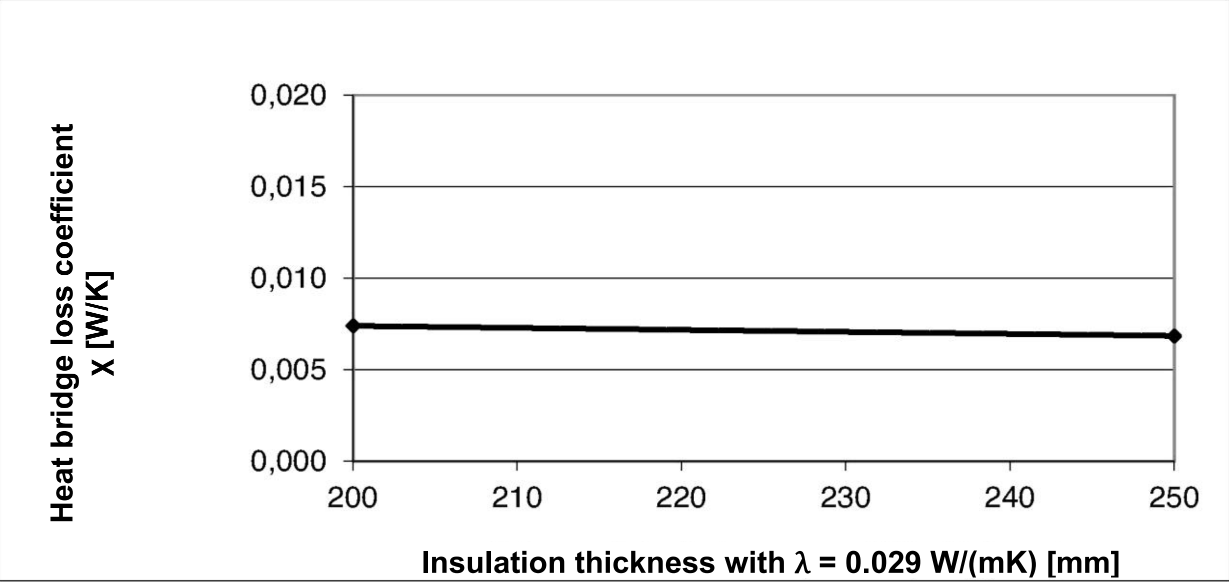

Fig. 6: Visualisation of the heat bridge loss coefficients (WLG 029)

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Insulation thickness [mm]	200	250
Insulation WLG	025	025
T_i [°C]	20.0	20.0
T_a [°C]	-10.0	-10.0
Model height [m]	1.20	1.20
Model width [m]	0.70	0.70
$Q_{Solido, undisturbed}$ [W]	2.99961	2.42290
$Q_{Solido, WB}$ [W]	3.23139	2.63961
$T_{min, WB}$ [°C]	19.43	19.52
U_{Wall} [W/(m²K)]	0.1190	0.0961
Ueq WB	0.1282	0.1047
χ_{WB} [W/K]	**0.00773**	**0.00722**

Table 8: Results of the heat flow simulation (WLG 025)

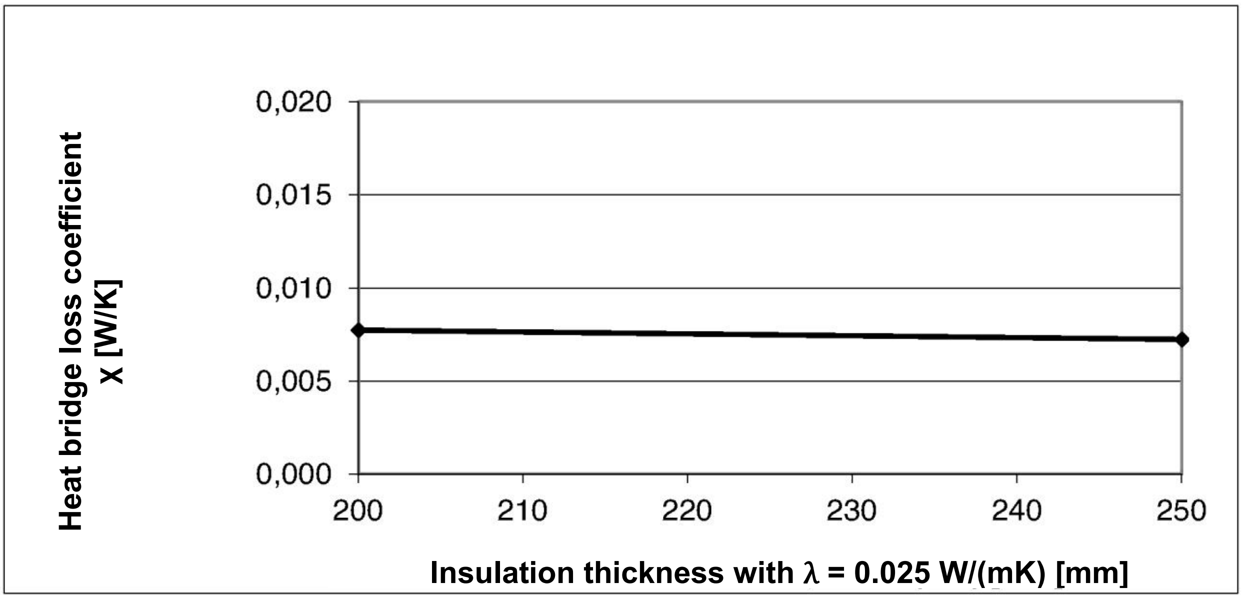

Fig. 7: Visualisation of the heat bridge loss coefficients (WLG 025)

The models and the associated isotherm graphs of the simulated system equipment carriers are represented below:

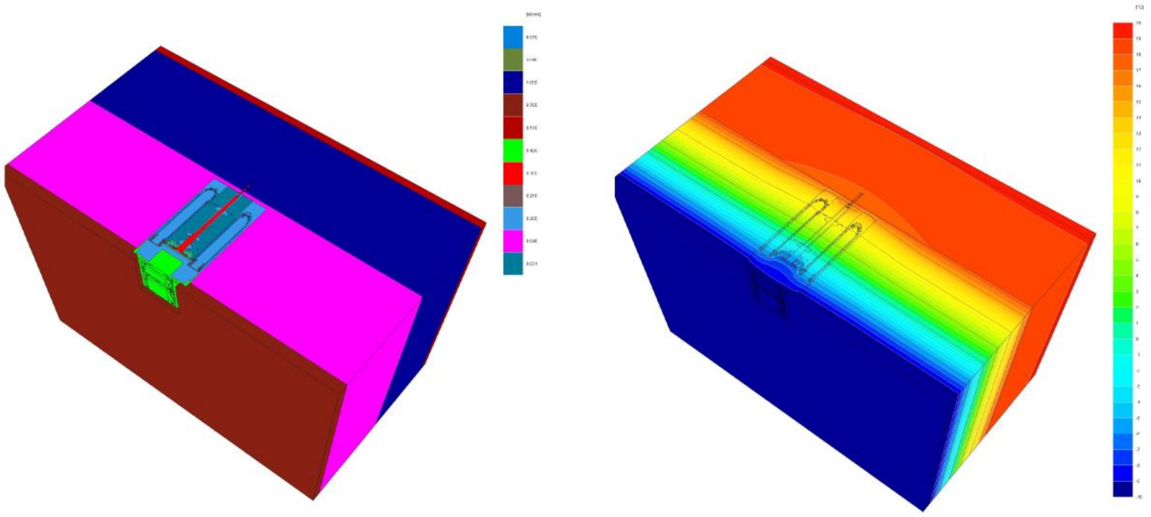

Fig. 8: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 040)

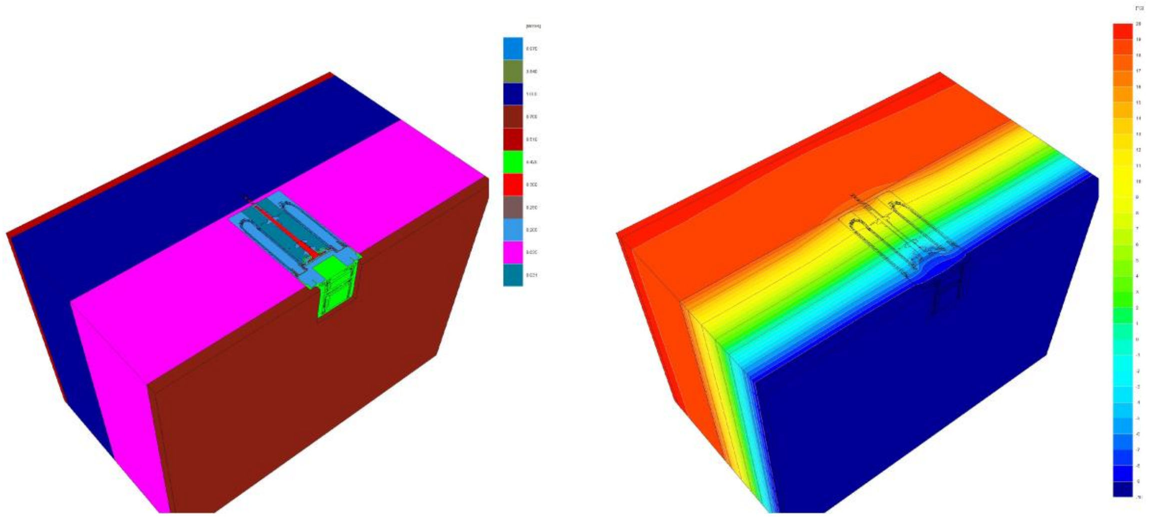

Fig. 9: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 035)

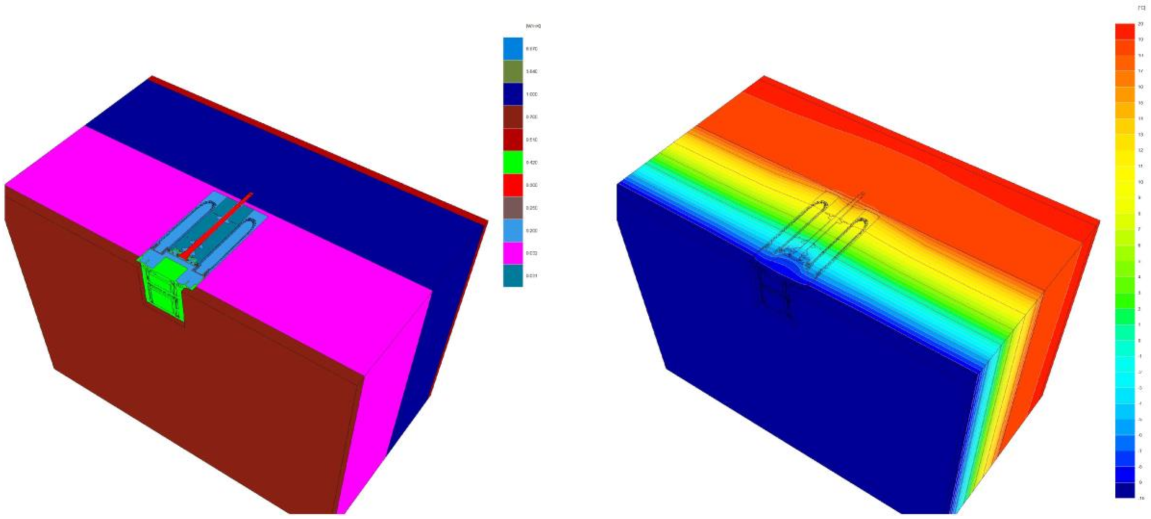

Fig. 10: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 032)

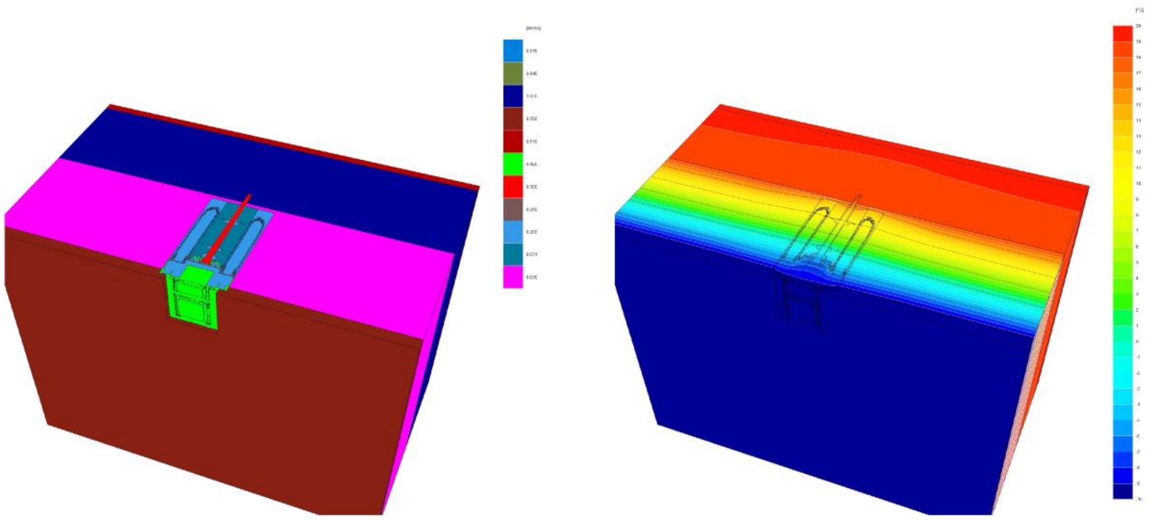

Fig. 11: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 030)

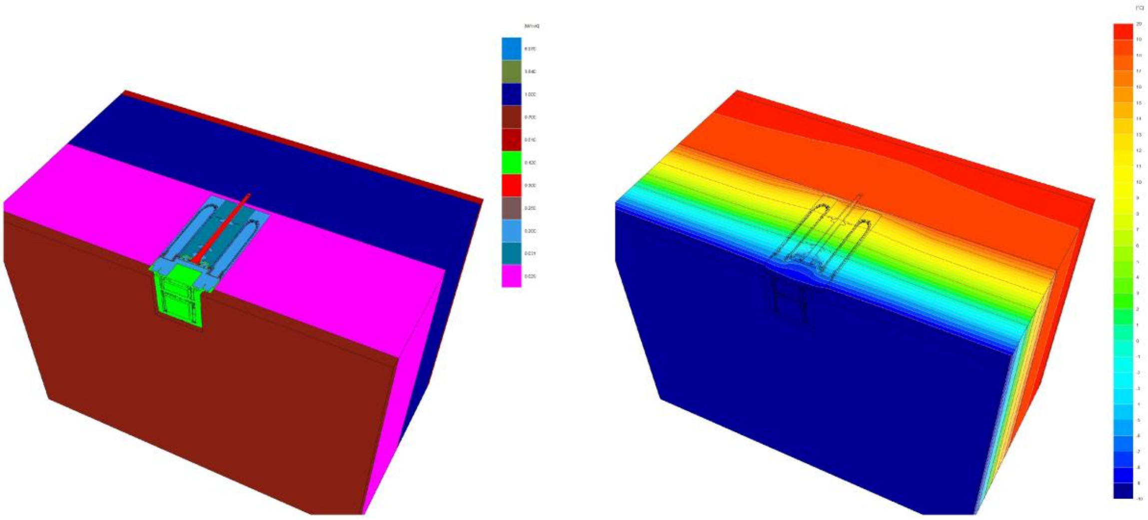

Fig. 12: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 029)

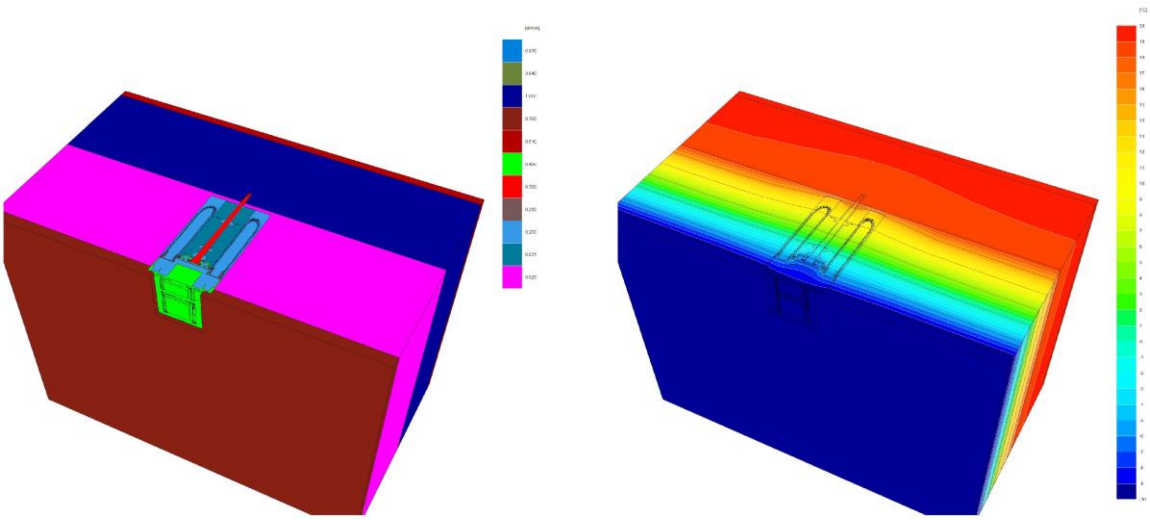

Fig. 13: Model and isothermal representation of 200 mm system equipment carrier in ETICS (200 mm, WLG 025)

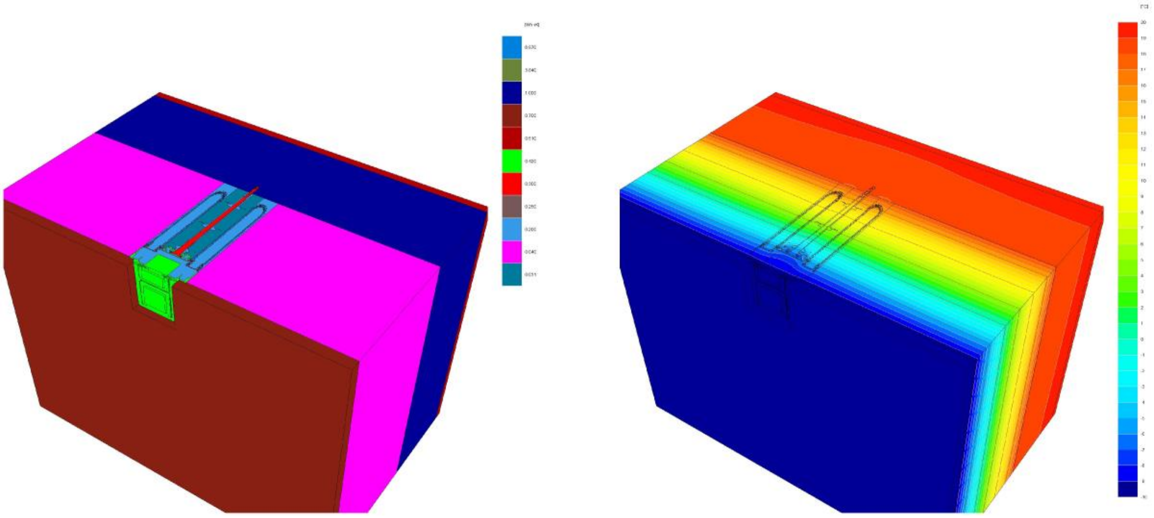

Fig. 14: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 040)

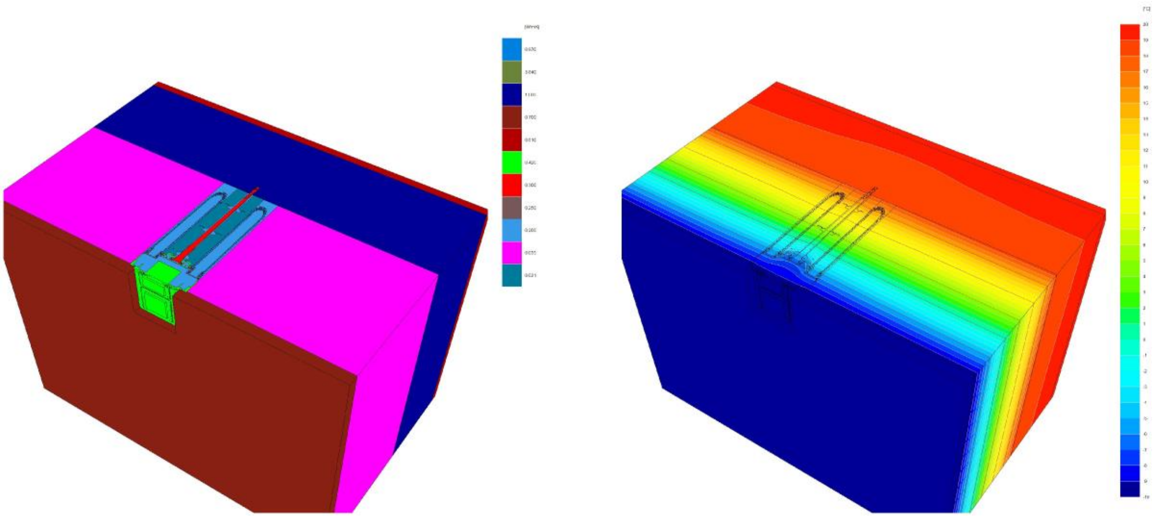

Fig. 15: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 035)

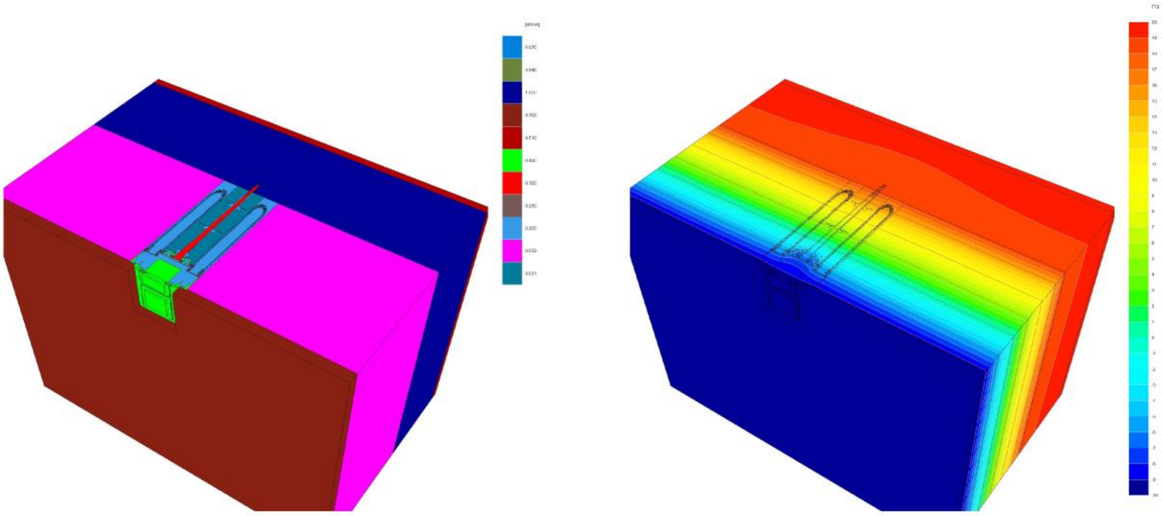

Fig. 16: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 032)

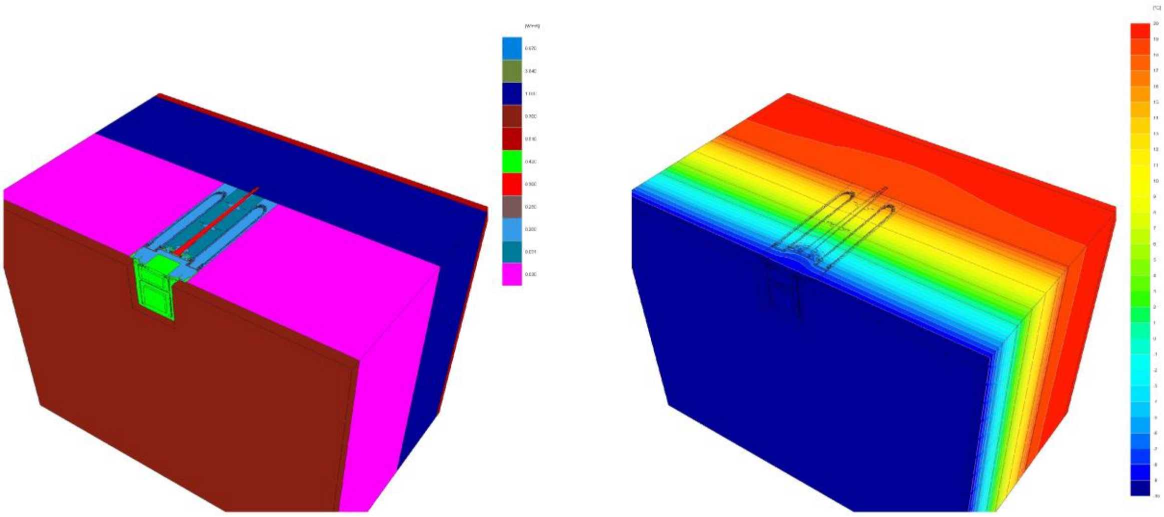

Fig. 17: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 030)

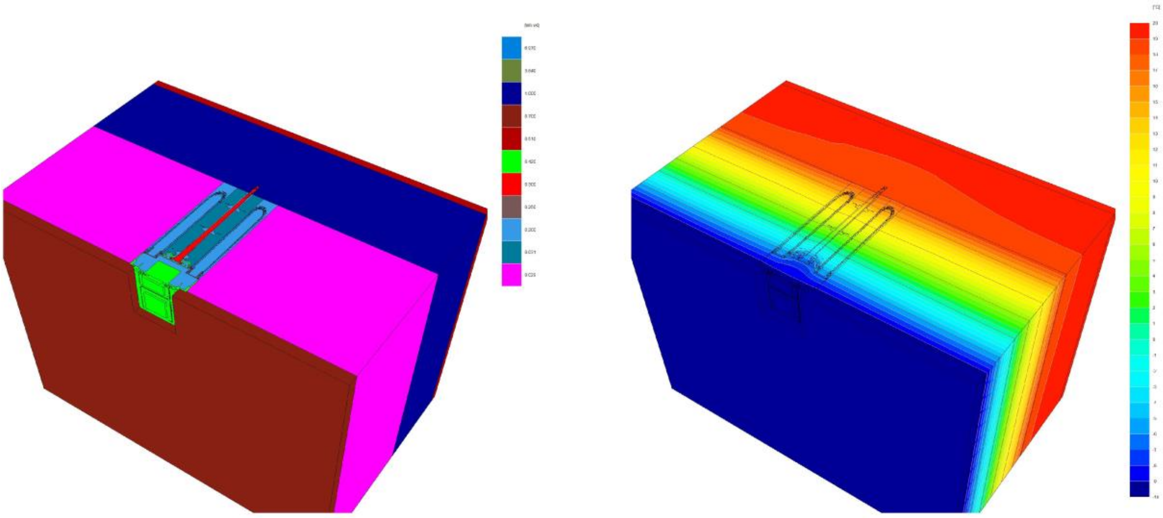

Fig. 18: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 029)

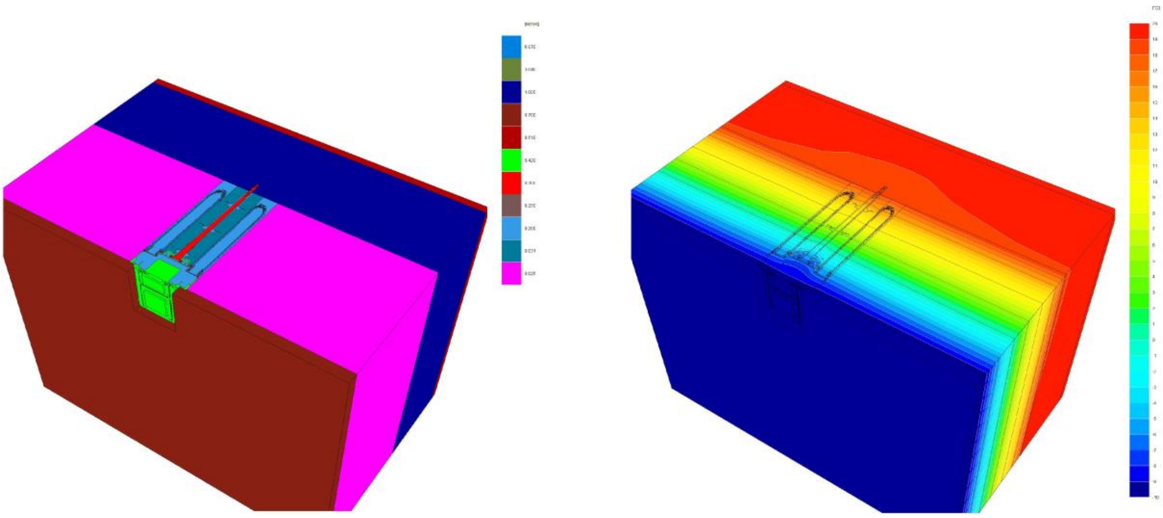

Fig. 19: Model and isothermal representation of 250 mm system equipment carrier in ETICS (250 mm, WLG 025)

Summary of the results

The system equipment carriers from Kaiser GmbH & Co. KG represent a successful design for heat bridge-free construction and can be recommended without reservation for use in highly heat insulated constructions.

An outstanding criterion for the construction of passive houses is the absence of heat bridges. All the variants analysed have a point heat bridge loss coefficient $\chi WB < 0.01$ W/K and therefore fulfil the requirements for heat bridge-free construction. The influence of the heat bridge is negligible and has no effect on the heating requirement of a building. The interior surface temperatures are well above the required 17°C for opaque building systems (on average even approx. 2.5 K higher). The high temperatures mean that damage due to increased water activity on the inside can be ruled out. Installation in accordance with the manufacturer's instructions is a prerequisite.

In order to determine the influence on the heating requirement, the heat bridge entry of the component was simulated in a projected passive house. Fig. 20 shows the energy balance with the system equipment carriers, Fig. 21 the energy balance of a standard solution with wooden substructure and dowels. The building is an apartment block (4 residential units) in which 4 system equipment carriers were used per residential unit. The difference in terms of the heating requirement is then approx. 0.4 kWh/m²a.

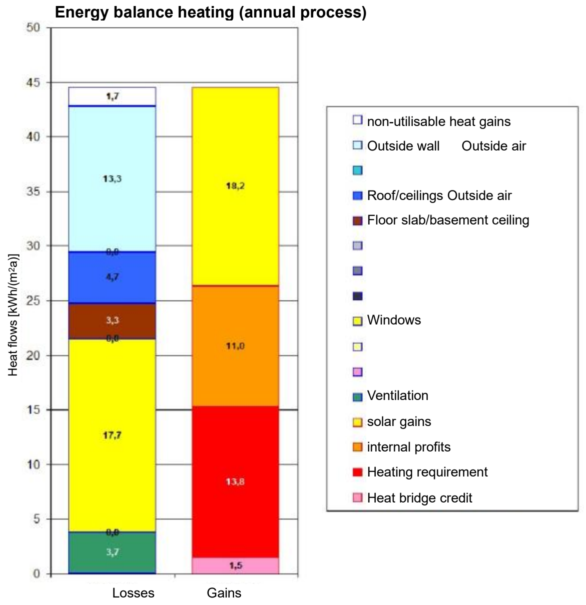

Fig. 20: Energy balance w. system equipment carrier

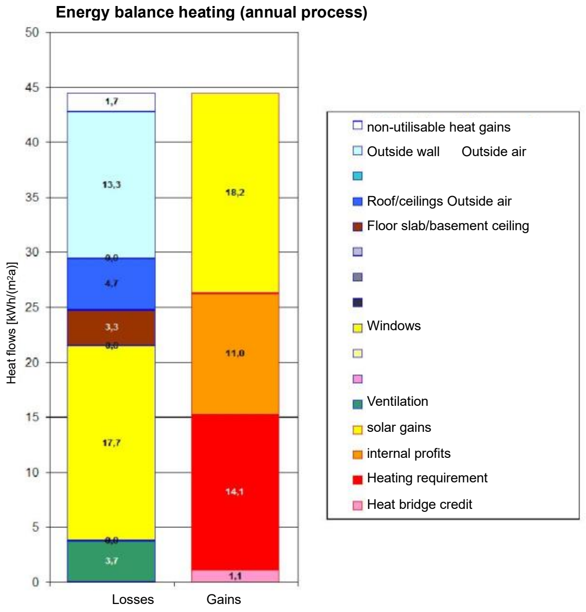

Fig. 21: Energy balance standard solution