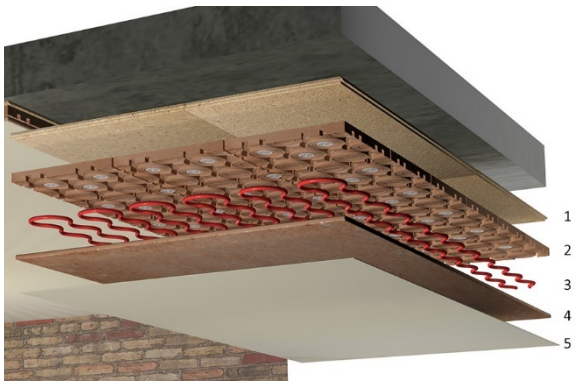
Natural climate ceilings as a modular system

The **electrical natural climate system** from ArgillaTherm combines the advantages of innovative direct heating technology with the positive properties of clay as a building material and relies on a newly developed, worldwide unique, and patented modular system.

Product manufacturing almost CO^2 neutral. 100% return to nature possible, cradle to cradle.

Sandwich construction



Components

1 OSB 3 / ESB-Plus P5 boards or in buildings with increased fire protection requirements cement-bonded chipboards with tongue and groove as substructure
2 High-performance clay modules according to DIN 18948 and Clay neutral panels according to DIN 18948
3 Electrical resistance cable in twin conductor technology, VDE-tested according to DIN IEC 60800 (ed.3):2009-07, pre-installed in various lengths and power ratings
4 Clay plaster "Thermo" according to DIN 18947 for surface heating and cooling systems with integrated mesh or Natural lime base plaster 66-20 for surface heating systems and cooling systems with integrated mesh
5 Clay paint according to DVL TM 06 as sprayable and brushable ready-mix

Core of the system

High Performance Clay Modules

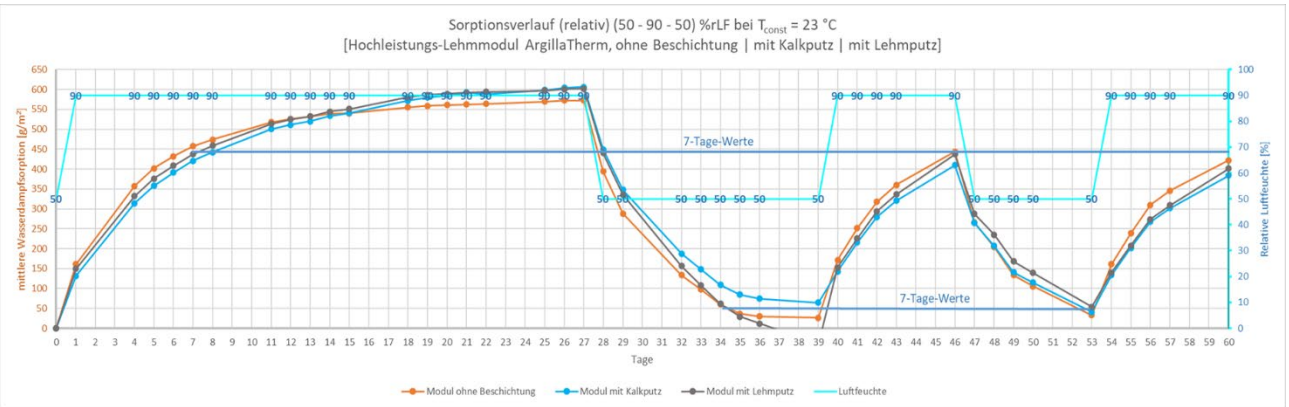
for easy & coupling-free laying of heating cables.
Highly absorbent, dimensionally stable, crack-free, without use of grid fabrics.
Moisture absorption according to standard = 107g/m² in 12 hours
Moisture absorption maximum > 500g/m²
Tested and certified.

composition:
Clays (≥ 35%), sands, brick dust, Miscanthus fibres
1m² = 7,23 Units High-performance Clay Modules

Humidity regulation

Sorption long-term measurements with humidity jumps 50% - 90% - 50% (relative humidity rLF), **carried out and tested by MFPA Weimar**.

Test specimen: High-Performance Clay Modules without coating
High-Performance Clay Modules with clay plaster coating
High-Performance Clay Modules with natural lime plaster coating



Result of the measurements:

The High Performance Clay modules can absorb more than 150 g of water vapor per m² within 24 hours and completely release it again within a very short time (desorption). After about 14 days, saturation is reached with a water vapor absorption of about 550g/m² at the simulated humidity jump of 40% rLF. No deformation, swelling or moisture penetration of the modules was observed, even over several weeks. The surface coatings (Argillatherm clay or lime plaster system) hardly influence the extreme sorption values of the High Performance Clay modules.

Hygrothermal material properties

determined by the Fraunhofer Institute

The Fraunhofer Institute determined the hygrothermal material parameters of the High-Performance Clay modules for moisture simulation in the room and created a corresponding data set for import into the WUFI program. If required, you can request the data set.

Bulk density: 1,800 kg/m³

Porosity (dry): 31,9%

Free saturation: 319 kg/m³ (700 kg/m³ by swelling)

Water absorption coefficient A value: 1.6 kg/m²√h

Water vapor diffusion resistance: μ = 22 (23°C/50rLF), μ = 10 (23°C/93rLF)

Technical data of the high-performance clay modules

Dimensions	**372 x 372 x 25 mm**
Weight per module	**5,74 kg**
Weight per m² (7.23 pieces)	**41,5 kg**
max. cable acceptance per m²	**11,8 m**
Building material class	**A 1**
Thermal conductivity	**High (1,05 W/mK)**
Moisture absorption and release in 12 hours	**> 100 Grammes per m²**

System partners

In order to be able to offer complete systems on the market, various cooperation agreements have been concluded with leading German manufacturers.

ArgillaTherm only uses system components that are subject to current standards and have been tested accordingly.

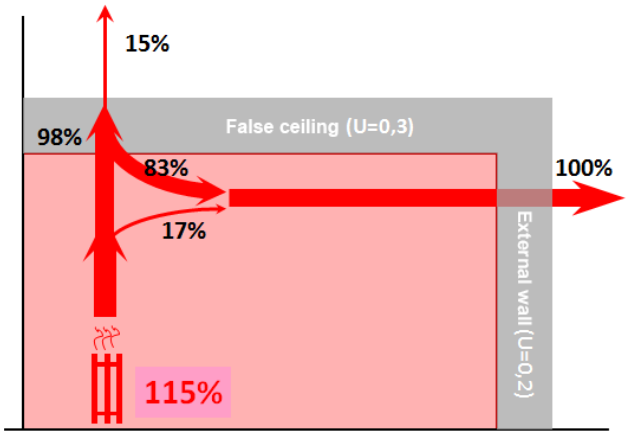
Firma Gräfix	Lime plasters	Special design
Firma Claytec	clay plasters & colours	Special design
Firma Hemstedt	Heating cable	Special design
Firma Eberle	Control engineering	Standard products with specially stored programs
Firma Protektor	Ceiling suspension	Standard products, axle mass according to test statics
Firma Spax	Fixings	Standard products
Firma Liaver	Acoustic system	Standard products

System tests carried out

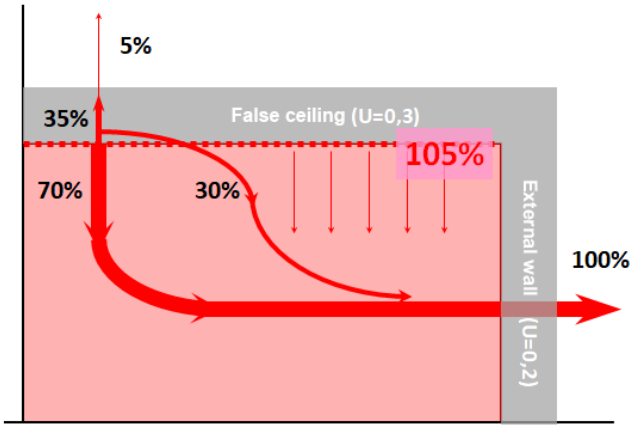
DIN EN 55014 DIN EN 61000 DIN EN 62233	Investigation of electromagnetic fields (EMF) and its compatibility and radiation (EMC)	VDE Offenbach
DIN 4102	Test for the classification of building materials according to their reaction to fire performance in fire resistance classes	MFPA Leipzig
DIN 18948	Requirements, performance characteristics and test methods for factory-made clay panels	MFPA Weimar
DIN 18947	Requirements for clay plaster mortar for plastering walls and ceilings	BAM Berlin

Sandwich construction

Comparison; heating systems with a high proportion of convection / ceiling heating systems with direct connection to the masonry (usually wet systems) compared to the ceiling heating from ArgillaTherm



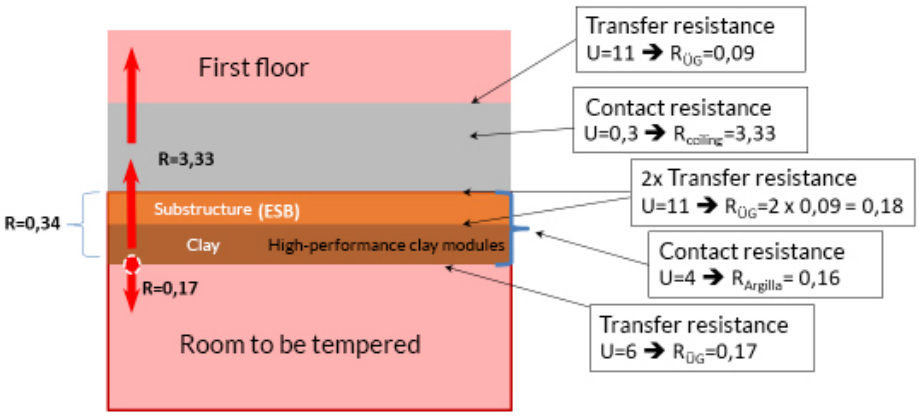
Heating systems with a high proportion convection or core activation



Ceiling heating from ArgillaTherm

The vagabonding heat on a typical winter day can be described by two parts: 1) The part that is stored in the false ceiling and 2) the part that escapes to the upper floor. Due to the sandwich construction, both proportions are significantly lower with ArgillaTherm's ceiling heating compared to heating systems with a high proportion of convection/ core activation.

Details about the thermal resistance due to the **sandwich construction** of the ArgillaTherm ceiling heating



The transfer resistance downwards is only about half of the total resistance upwards (transfer and contact resistances). Therefore about 2/3 of the heat goes directly into the room and 1/3 into the clay layer of the ArgillaTherm system building board. From there, a large part comes back again, because the resistance into the floor above is much higher than back into the clay panel.

Heating, automatic humidity control, permanent room air cleaning and optionally via additional modules a pleasant acoustics with only one surface.

Fields of application

The electric natural climate ceiling system is ideally suited for use in single and multi-family houses with an annual energy requirement of max. 60 KWh/m².

Very good conditions are given for the conversion of night storage heaters, as the existing infrastructure such as the electrical lines to the electricity meter box can still be used.

Reaction time / thermal inertia

The response time is about 5 minutes, and the high-performance clay modules, including the plaster covering, are completely heated through after about 60 minutes. If the energy supply is interrupted, the system keeps the surface temperature relatively constant for about 60 minutes, depending on the environment, due to the enormously high storage capacity of the high-performance clay modules. This means that low-cost heating current tariffs can be used for "permanently installed interruptible consumption equipment" (§ 14a of the technical connection conditions (TAB) from the grid operator).

Ceiling assignment

Full ceiling coverage (variant I)

Depending on the required heat output, the entire ceiling area is covered with high-performance clay modules and clay neutral panels.

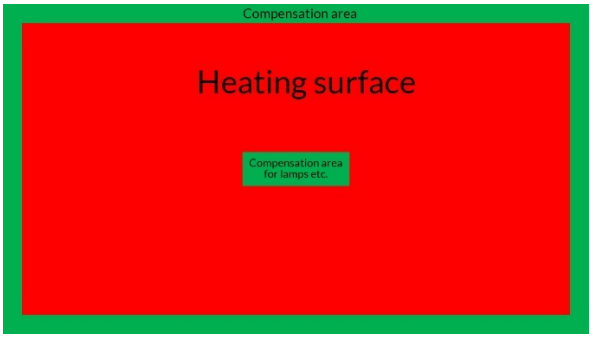
Partially covered ceiling without compensation area (Variant II)

The ceiling is only covered with high-performance clay modules, the remaining area remains free. This creates a raised heating surface. The ceiling heating becomes a design element.

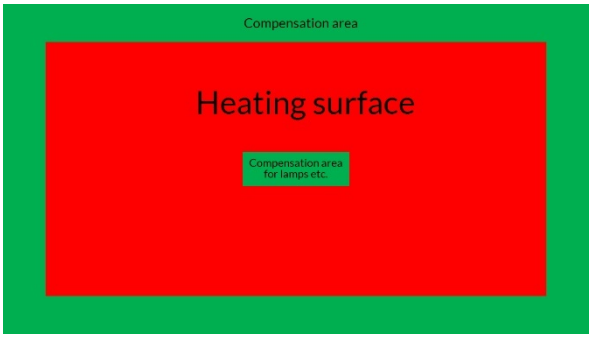
Variant I (full area allocation)

Variant II (partially covered ceiling without compensation area)

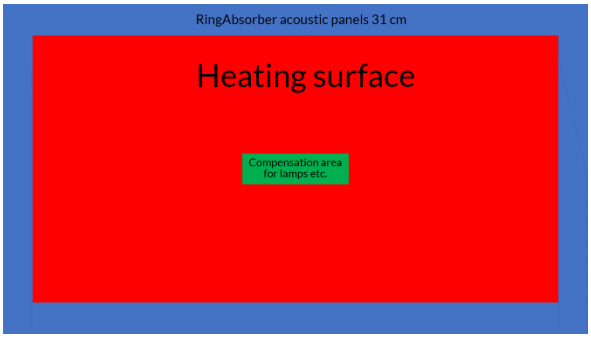
Variant ceiling heating with full surface coverage



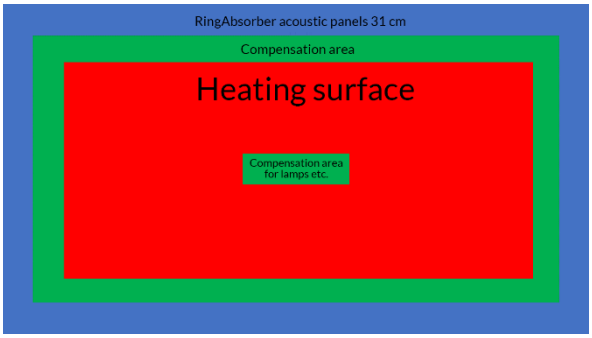
Maximum heating power



Reduced heating power

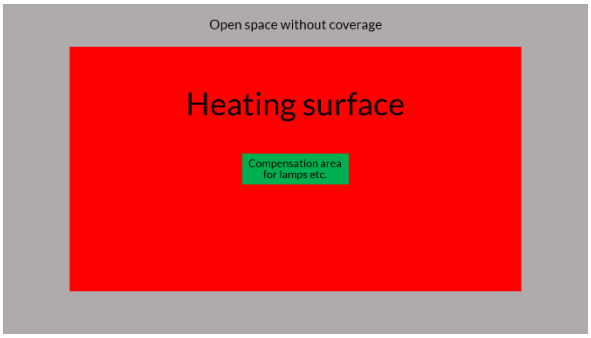


Maximum heating power with RingAbsorber acoustic panels

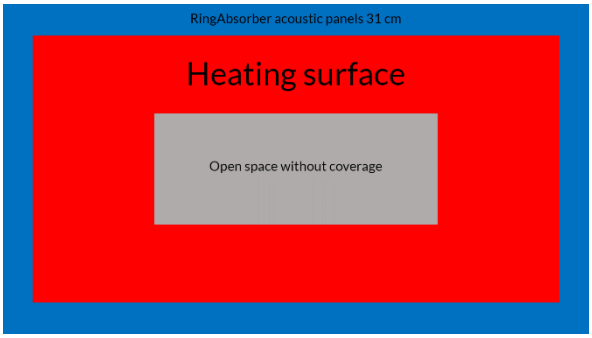


Lower heat output with RingAbsorber acoustic panels

Variant ceiling heating for partial coverage



Ceiling heating interior



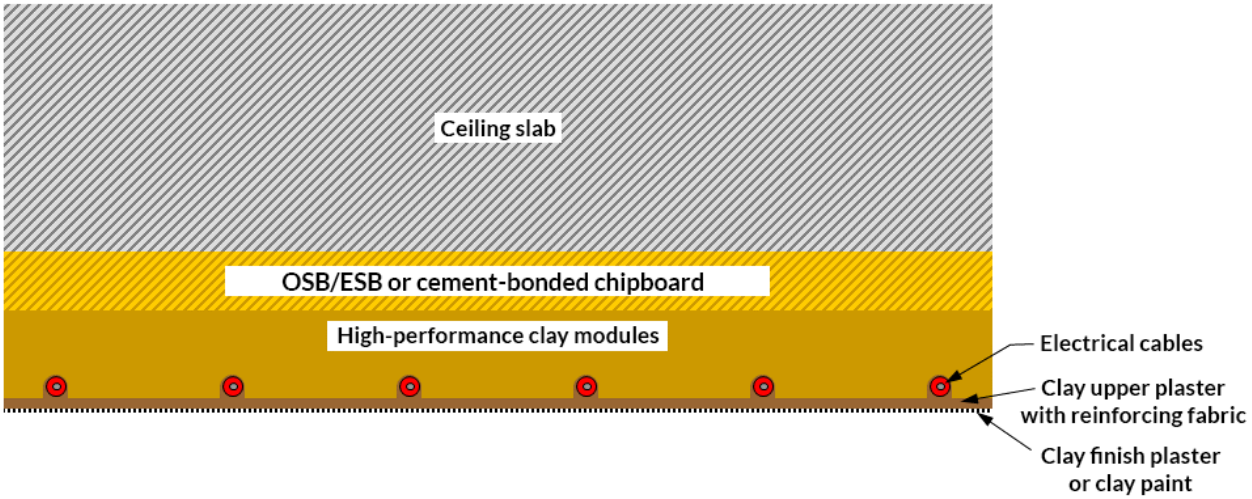
Ceiling heating external with RingAbsorber acoustic panels

Ceiling heating external

Mounting variants / system structure

Example 1:

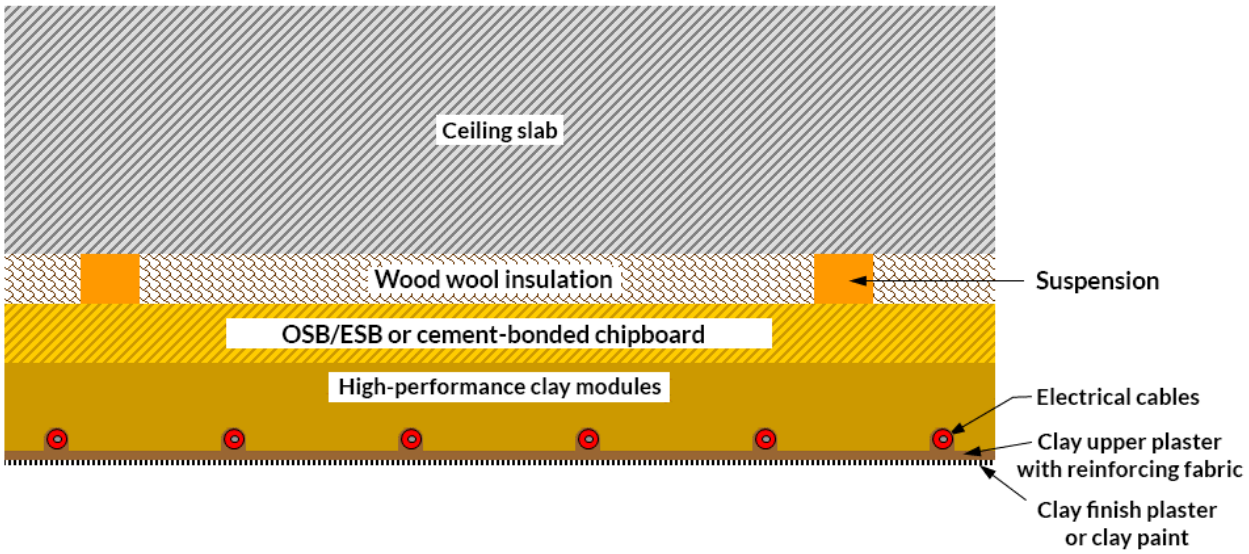
direct fastening with OSB/ESB or cement-bonded chipboard on the ceiling / installation height 52mm



The surface coating can be done as described with clay plaster and clay paint, and with lime plaster and lime paint. The decisive factor is the permeability of the cover material, so that the sorption capacity of the High Performance clay modules is not is significantly affected.

Example 2:

Fixing with substructure formwork, cavity insulation and OSB/ESB or cement-bonded chipboard / installation height 52mm plus suspension

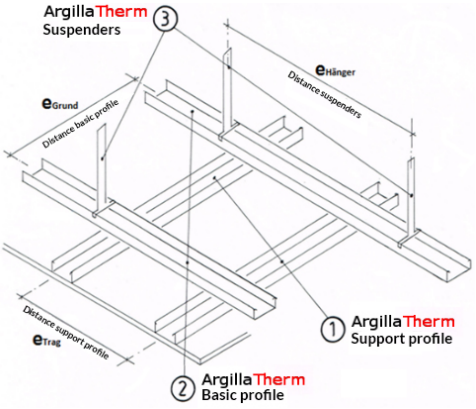


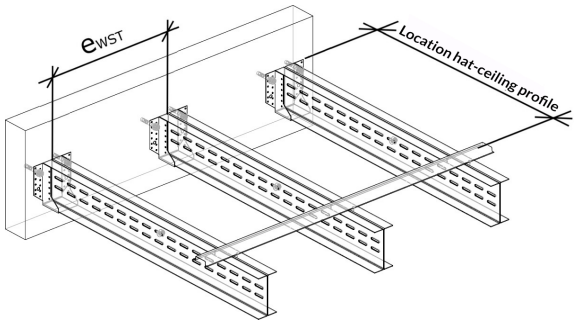
The surface coating can be applied as described with clay plaster and clay paint, or with lime plaster and clay paint. The decisive factor is the permeability of the covering material, so that the sorption capacity of the High Performance Clay Modules is not affected.

Example 3: Statically tested metal ceiling suspension in lightweight construction

a) with nonius connectors for ceiling mounting
75kg load capacity (for UK made of 22mm OSB/ESB boards)
Axis dimension CD basic profile = 600mm
Axis dimension CD support profile = 600mm
Distance Nonius-Pendant = 600mm
85kg load capacity (for UK from 18mm CETRIS boards)
Axis dimension CD basic profile = 550mm
Axis dimension CD support profile = 550mm
Distance Nonius-Pendant = 550mm

b) self-supporting with wall mounting for significant reduction of impact sound





Technical planning and basics

When planning and designing the ArgillaTherm® natural climate ceilings, the relevant regulations and standards must be taken into account.

DIN EN 12831	Method for calculating the standard heating load
DIN IEC 60800	Requirements for electrical resistance cables
DIN EN 60730	Automatic electrical regulation and control devices
DIN 18947	Requirements for clay plaster mortar for plastering walls and ceilings
DIN 18948	Performance characteristics and test methods for factory made clay building boards
DVL TM 06	Technical data sheet for clay thin-layer coatings of walls & ceilings

The work of the trades involved in the construction process must be coordinated accordingly.

Planning: Energy Consultant/Architect / Planner

Performing trades: electrician/drywall builder/construction company

Electrical resistance cable

The VDE-tested resistance heating cable according to DIN IEC 60800 (ed.3):2009-07, consists of a red heating cable (available in different lengths and power ratings) and a 4m long connection cable (PTC thermistor). The seamless transition from the connecting cable to the heating cable is absolutely waterproof and ideally suited for installation in the eSYSTEM.

The heating cable consists of a solid heating conductor with insulating sheath, a solid copper return conductor with insulating sheath and a solid copper ground fault conductor. An aluminium sheath with external insulation forms the termination of the heating cable.

Image of seamless transition; connection to heating cable

Note: According to the European Ecodesign Directive, thermostats that meet the requirements of LOT 20 must be used.

Product range 12W/m heating cable

Heat output in W	Length heating conductor in m*	Item number
150	12,07	EHK001207
450	35,97	EHK003597
750	59,87	EHK005987
1500	119,37	EHK011937
2250	179,37	EHK017937

all cables are pre-installed with a 4 m long connection cable (seamless transition)

Maximum occupancy per m² high-efficiency clay module: 11.8 m ≙ approx. 140 Watt/m² heating capacity without surface temperature limitation.

Product range 5.8W/m heating cable

Heat output in W	Length heating conductor in m*	Item number
70	12,07	EHK101207
210	35,97	EHK103597
350	59,87	EHK105987
490	83,87	EHK108387
700	119,37	EHK111937

all cables are pre-installed with a 4 m long connection cable (seamless transition)

Maximum occupancy per m² high-performance clay module: 11.8 m ≙ approx. 70 Watt/m² heating capacity without surface temperature limit.

No electric smog! Due to the heating cable design, the twin conductor technology used and the cable embedding in the clay, the heating system is completely free of any kind of electromagnetic radiation. This has been tested at the VDE Testing and Certification Institute in Offenbach and confirmed accordingly in the test report.

Design of ceiling heating

The average surface temperature for ceiling systems with a height of up to 3 metres should not exceed 32°C according to the standard specification.

For ceiling heights above 3 metres, the average surface temperature can be higher and should be adjusted accordingly according to DIN EN ISO 7730.

Lower heating outputs are achieved either by reducing the surface temperatures or by reducing the surface area of high-performance clay modules while maintaining the same surface temperatures. The remaining surfaces remain free or are covered with clay neutral panels.

Ceiling Temperature in °C	Room Temperature in °C	Heat output Watt/m²
40,0	20	120
37,5	20	105
35,0	20	90
32,5	20	75
30,0	20	60
27,5	20	45
25,0	20	30
22,5	20	15

Self-heating effect of the high-performance clay modules

The heat generated in the room during the day rises to the ceiling by convection (warm air). Heat sources can be e.g. people, electrical devices or incident solar energy. ArgillaTherm's highly compressed clay modules store this heat energy and the sandwich construction prevents the heat from migrating to the ceiling. If the room temperature falls below the temperature of the clay layer, the stored energy is released back into the room in the form of thermal radiation. The heating period is thus reduced by up to 6 weeks in the transition periods. Detailed information about this under: Lehmbau Handbook, building material science, techniques of loam architecture; Prof. Dr. Gernot Minke.

Ceiling cooling in buildings with passive cooling by night ventilation

B By using the High Performance Clay Modules and the resulting uniquely large moisture reservoir (> 500g/m²), this system is ideally suited for use in buildings with passive cooling through night ventilation. The functionality is as follows:

Night: Charging the modules with cool moisture and convective release of the stored thermal energy from the day in the air flowing past.

Day: Release of stored moisture and absorption of room heat (mainly convective).

100g moisture evaporation ≙ 62.5Wh/m² evaporative cooling in a natural way. The cooling capacity can be further increased by using geothermal heat exchangers. Room temperature reduction around 8°C to the outside temperature peak can be displayed without any problems.

KFW classification according to GEG 2020

Three EFH model houses (small. medium, large) with normal window area (20%) and large window area (40%) were built according to Fig.1. and varied in building envelope, ventilation system with heat recovery and size of the photovoltaic system to such an extent that the entire range from "GEG just fulfilled" to "KfW40" was covered. The result is shown in Fig.2.

House type A:
floor space = 8 x 10m
ground floor & top floor
PV system = maximum 6 kWp

House type B:
floor space = 10 x 12m
ground floor & top floor & pointed bottom
PV system = maximum 12 kWp

House type C:
floor space = 12 x 14m
ground floor & top floor & pointed bottom
PV system = maximum 13,5 kWp

Fig.1:
Three house types with different floor space and state of construction (basement, attic) were considered. In addition, the proportion of windows was varied (20% and 40% of the wall proportion).
Due to the different size, the maximum PV system is also different in size. As the calculation showed, the achievement of the required H'T value with a fully occupied roof usually correlates with the achievement of the respective KfW standard (40,55,70).

Fig. 2: The following table shows what a KfW standard can be achieved taking into account insulation, ventilation system with heat recovery and photovoltaic system.

No.	House type	HT value of the building	Window share	Ventilation with WRG	PV system	KfW class
1	A	0,3	20%	80%	5 kWp	GEG
2	A	0,29	20%	80%	6 kWp	70
3	A	0,25	20%	80%	6 kWp	55
4	A	0,19	20%	80%	6 kWp	40
5	B	0,33	20%	80%	12 kWp	GEG
6	B	0,3	20%	80%	10 kWp	70
7	B	0,25	20%	80%	10 kWp	55
8	B	0,2	20%	80%	10 kWp	40
9	B	0,2	20%	0%	10 kWp	70
10	B	0,22	20%	0%	12 kWp	70
11	B	0,27	40%	0%	12 kWp	70
12	B	0,24	40%	80%	12 kWp	40
13	C	0,2	20%	80%	13,5 kWp	40
14	C	0,2	20%	0%	13,5 kWp	70
15	C	0,31	20%	80%	13,5 kWp	70
16	C	0,31	20%	80%	10,5 kWp	GEG
17	C	0,33	20%	80%	13,5 kWp	GEG

As a rule of thumb, if an appropriately dimensioned photovoltaic system and a ventilation system with heat recovery are installed, one remains in the targeted KfW class without having to improve the building envelope or the HT value. To achieve a KfW70 standard, the HT value of the building must be 0.3 and a KfW40 standard 0.2.

Statics

Ceiling loads are calculated and designed according to DIN 1055. This specifies a load-bearing capacity of 1.5 or 2.0kN/m² for today's residential buildings. For older buildings with wooden beam ceilings, the load design is similar and is usually 1.5kN/m². 1kN corresponds to about 100kg.

Weight High Performance Clay Modules	41,50 KG/m²
Weight Clay neutral panels	15,50 KG/m²
Weight Fixing material, heating cable and lime plaster without substructure	15,00 KG/m²
Weight Fixing material, heating cable and clay plaster without substructure	17,00 KG/m²
Weight Fixing material, heating cable and lime plaster and 22mm OSB/ESB board	28,20 KG/m²
Weight Fixing material, heating cable and clay plaster and 22mm OSB/ESB board	30,20 KG/m²
Weight Fixing material, heating cable and lime plaster and 18mm cement bonded particleboard	40,60 KG/m²
Weight Fixing material, heating cable and clay plaster and 18mm cement bonded particleboard	42,60 KG/m²

Example: 20m² of ceiling; 50% high performance clay modules and 50% clay neutral panels
and a substructure of 22mm OSB boards, surface coating with lime plaster.
==> 10m² x 69,70KG (41,50KG + 28,20KG) and 10 x 43,70KG (15,50KG + 28,20KG) = 1.134 KG
==> 56,70KG/m² average weight

The maximum weight is 71.7 KG/m² (when fully loaded with high-performance clay modules) and a Surface coating with clay plaster.

Required materials per m² heating surface with surface coating lime plaster

OSB/ESB or cement-bonded chipboard with tongue and groove as substructure	1 m²
High-performance clay modules according to DIN 18948	7,23 piece
Stainless steel – screw load distribution disc 5 x 50 mm & stainless steel - clamping screw 5 x 45mm	18 piece
Electrical resistance cable in twin conductor technology, VDE-tested	11,8 m
Natural lime base plaster 66-20	10 kg
Glass silk mesh fabric, MW 7 x 7mm, 105g/m², 100cm wide	1 m²
Clay paint according to DVL TM 06 as sprayable and brushable ready mix (2x coat)	1 kg
Natural lime finish plaster 685-20 (optional)	*2 kg*

Required materials per m² heating surface with surface coating clay plaster

OSB/ESB or cement-bonded chipboard with tongue and groove as substructure	1 m²
High-performance clay modules according to DIN 18948	7,23 piece
Stainless steel - screw load distribution disc 5 x 50 mm & stainless steel - clamping screw 5 x 45mm	18 piece
Electrical resistance cable in twin conductor technology, VDE-tested	11,8 m
Clay plaster „Thermo“ according to DIN 18947	12,5 kg
Glass silk mesh fabric, MW 7 x 7mm, 105g/m², 100cm wide	1 m²
Clay paint according to DVL TM 06 as sprayable and brushable ready mix (2x coat)	1 kg
High-grade clay plaster according to DVL TM 06 with 2mm application thickness (optional)	*3,5 kg*

Coatings and surfaces

Variants	Full surface plaster layer with fabric reinforcement	Surface finish
Standard lime	**Natural lime HP 66-20**	**Mineral paint medium**
Lime 02	Natural lime HP 66-20	Clay roll plaster fine
Lime 03	Natural lime HP 66-20	Natural lime smooth HP 66-K
Lime 04	Natural lime HP 66-20	Natural lime smooth HP 66-K with clay paint
Standard clay	**Clay plaster Thermo**	**Clay roll plaster fine**
Clay 02	Clay plaster Thermo	Clay roll plaster coarse
Clay 03	Clay plaster Thermo	Clay finishing plaster
Clay 04	Clay plaster Thermo	Clay finishing plaster with clay paint