BEKA ceiling heating versus traditional underfloor heating

0. Preliminary remark

In the future, rooms will be heated and cooled by surfaces providing radiant heating and cooling. The heating technology sector is convinced of this. The growth rates for underfloor heating systems are impressive. In Germany, underfloor heating is already installed in 50% of all newly constructed detached homes. But underfloor heating is also becoming more and more common in the retrofit market. The reasons for this development are easy to understand. Surface heating uses lower supply temperatures than radiator technology. So it is economically possible to use environmental heat as the heat source. Surface heating and cooling ensure a high level of comfort and pleasant warmth without the technology visibly influencing the interior design.

The article below was written with this in mind.

1. Criticism of traditional underfloor heating

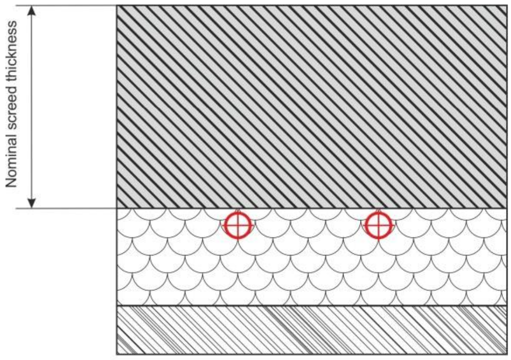
Conventional hot water underfloor heating – the technology currently dominating the market – is more than 60 years old. It is proven technology in theory and practice, and is frequently used today. The common systems do not vary significantly in terms of their technical solutions. All of these systems contain tubes arranged in meanders or spirals. The tubes are generally made of plastic. They have an external diameter of 14 to 17 mm and the distance between them in situ is usually at least 150 mm.

Plastic tubes made of multi-layer bonded material are becoming increasingly common for underfloor heating. But these materials cannot be separated for recycling using today's technology and are therefore viewed critically when it comes to dismantling. Manufacturers justify this material quality with the need for a diffusion barrier in order to prevent ingress of oxygen and thus be certain of avoiding corrosion in the systems. However, it is impossible to ensure total avoidance of corrosion. Such constructions only reduce the quantity of oxygen entering the system. Entry of oxygen is inevitable at all screw fittings and seals and always leads to corrosion and sludge build-up. At best, diffusion barriers in the plastic tubes only put off the time when failure occurs due to corrosion. But even this does not have a clearly defined timeframe, as ageing both of the plastic and of the barrier layer in the bonded material alters the diffusion properties.

Heat transfer into the room by underfloor heating is around 60% radiation and 40% convection (warm air rises). In addition, the occupants of the room absorb heat directly through the contact between their feet and the floor. The convection/air movement in the room transports suspended matter/germs from the floor that rise into the space where people spend their time. This germ-laden flow of air irritates the airways and the mucous membranes. And a considerable number of people also find the warmth at their feet to be unpleasant. Pets also prefer the inactive areas when the heating is operating at full capacity. However agreeable it is to have warm feet after being chilled, over a longer period heat from below is felt to have adverse effects on the blood vessels in the feet and legs.

Due to building floor thermal resistance, energy that does not contribute to heating the room is used (and wasted) when heat is transferred from the temperature of water heating the underfloor system tubes to surface temperature, which then heats the room. The greater the thermal resistance, the lower the efficiency of the heating system, especially with technology involving environmental heat, such as heat pumps. Very often, the desired room design prescribes surface sealing of the floor, such as parquet floors, cork coverings or carpeting. However, this additionally worsens the energy efficiency of the heating system. For this reason, when a new floor covering is chosen for an area with underfloor heating, it should be given a critical assessment – particularly in retrofitting. The efficiency of the heating system is always affected.

The construction of traditional underfloor heating takes up some of the room height. It is true that this is almost negligible in new buildings, but in retrofitting projects subsequent costs may arise from adjusting the heights of doors, or the labour-intensive removal of the existing floor. In partial upgrading, it is not uncommon to find that after underfloor heating has been installed, not all floors in the dwelling are at the same level.



Screed thickness:	60 mm in total
Insulation thickness	35 mm
Total:	95 mm

Construction type B:
Sprung floor with pipes laid in the insulation layer under the screed

Source:
Directive No. 3 of the Federal Association of Surface Heating and Surface Cooling (BVF)

The difficulty of regulating traditional underfloor heating is a well-known problem linked to construction itself. Elaborate control systems that anticipate demand do not deliver the desired effect – or only to a limited degree. When the temperature changes for a short period, as a rule the heating system takes 5 hours or more to react.

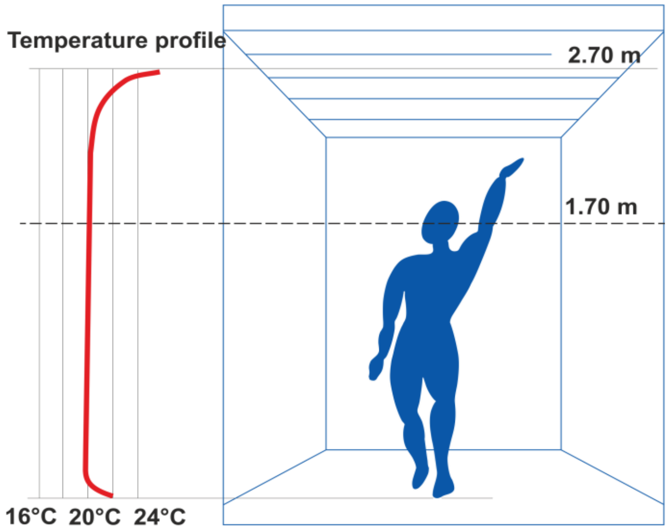
2. *BEKA ceiling heating*

The motto "learning from nature" explains why ceiling heating is meaningful. The thermodynamic principle that "warm air rises and cold air falls" is not what drives ceiling heating. Instead, the heat is largely radiated from the ceiling into the room. There is much less heat transfer by convection in the case of ceiling heating than with underfloor heating.

Yet the heating capacity of the ceiling is sufficient to warm the room up completely. Modern houses – and modernised houses – have a rather low heating requirement by today's standards, of a maximum of 60 W/m^2 and generally much lower. This was not the case in the past and therefore ceiling heating systems were operated with surface temperatures exceeding thermo-physiological limits, which is why the heat radiation was felt to be unpleasant.

Today's control systems are also better than in the past. Room temperature can now be regulated more precisely. Also, the very precise control behaviour of BEKA ceiling heating is much different from the old technology. BEKA ceiling heating reacts swiftly and always keeps the room at the required temperature. The surface of the ceiling reaches the new temperature in less than 15 minutes, and the heating process begins. BEKA ceiling heating systems are self-regulating once they reach the desired room temperature. The room's thermostat switches on the heating valve of the heating circuit only as needed. The radiated heat reaches and warms every corner of the room. This generates an almost even all-round temperature on all surfaces. The surfaces take up the heat and store it. If the heating is interrupted, the surfaces continue the warming action. So there is no disruption if some heat is lost when windows are opened briefly to ventilate the room. The room quickly returns to the desired temperature afterwards.

Heat from above is also healthy and well tolerated. Since hardly any convection takes place, there is very little air movement which would transport germs or dirt. In rooms of normal height – over 2.60 m – a constant temperature is established in the living area. The floor is warmed slightly due to absorption and reflection and reaches a temperature slightly above that of the room itself.



BEKA ceiling heating should preferably be integrated in thin layers in the ceiling construction. With plaster ceilings, this means that a layer of plaster only 15 mm thick is sufficient to cover the capillary tubes. But also any conventional suspended ceiling construction made of gypsum plasterboard or a metal cassette ceiling can be activated for ceiling heating without any problem.

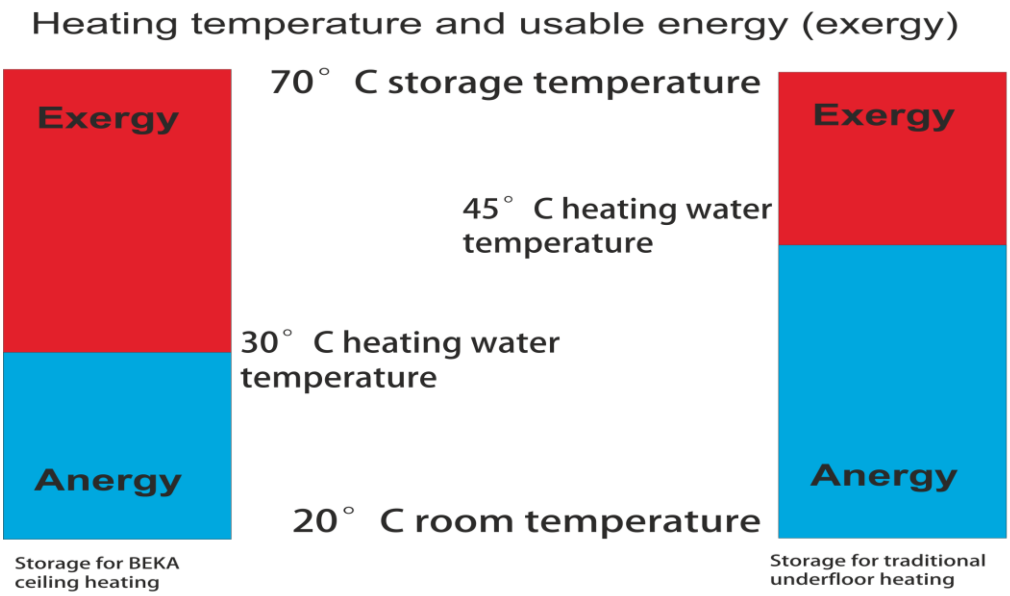
BEKA ceiling heating demands a system designed to be resistant to corrosion throughout. All the components should be made of corrosion-resistant materials. This on its own ensures the reliability of the entire system and thus a long service life, therefore avoiding unnecessary service and maintenance costs.

3. Comparison of energy efficiency

The energy efficiency of a heating system is described by the necessary amount of energy that has to be expended to maintain the desired room temperature. Only the additional energy needed requires input and leads to operating and consumption costs. The supply temperature is thus the parameter that determines the efficiency, because in most cases supply temperature is raised to the level required for the system by input of additional energy.

A low supply temperature saves energy. And savings start with the provision of such temperature. For instance, a low supply temperature can be obtained with less additional energy input from ambient heat than is required by a higher supply temperature. Heat pump technology is one example that can illustrate this connection very quickly. Low supply temperature = less additional electrical energy is required; high supply temperature = more additional electrical energy is required.

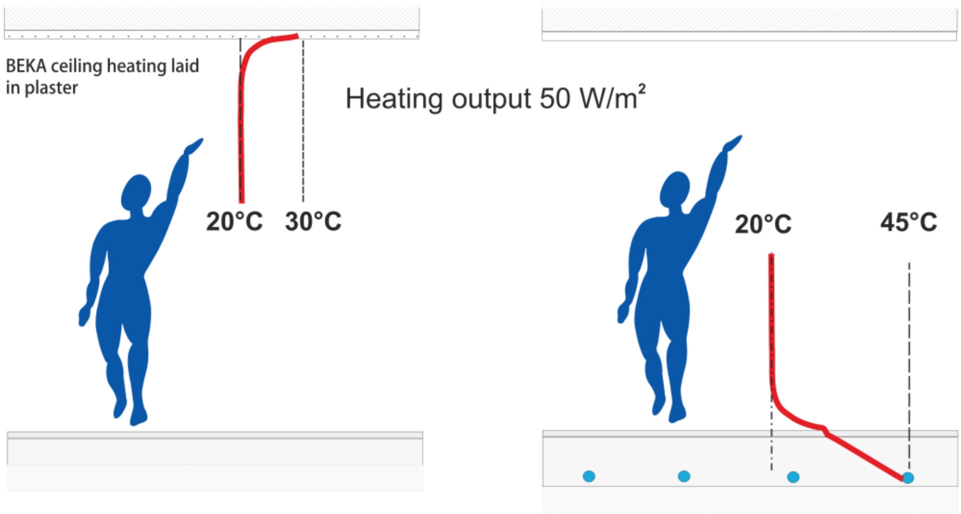
But stored heat can also be used more efficiently and over a longer period by technology using lower supply temperatures, than by technology requiring high supply temperatures. The proportion of usable storage energy (exergy) is higher in technology with reduced supply temperature. Where BEKA ceiling heating is used, the stored energy does not have to be replenished as quickly. If energy is wholly or partly stored by using environmental heat, systems can either be designed to be smaller or to retain the required heating energy for a longer period.



BEKA ceilling heating vs. underfloor heating

BEKA ceiling heating requires a much lower supply temperature than traditional underfloor heating to transfer the same amount of heat. This is a result of construction. The thin capillary tubes are directly below the surface of the ceiling and covered only by a thin layer. This thin covering presents hardly any resistance to the flow of heat. Heat is conducted from the heating water to the ceiling surface with virtually no loss of temperature. Furthermore, the large number of densely packed capillary tubes (10 to 15 mm apart) results in the heat being very evenly distributed over the entire ceiling surface.

The conduction of heat from the heating water to the floor surface is different with traditional underfloor heating. The thick heating tubes demand a thick layer of screed above the tubes for structural reasons. Accordingly, there is high thermal resistance from the screed and the floor covering (carpet, laminate, parquet, etc.). Therefore a higher supply temperature is required to drive the flow of heat to the surface. The "heating" screed should simultaneously serve to somewhat even out the temperature between the heating tubes that are fairly far apart in the screed – this should help to smooth out a strong ripple in the surface temperature. This construction is, however, only moderately successful in comparison with the even surface temperature achieved with BEKA ceiling heating. That is not only evidenced by thermographic imaging, but can also definitely be felt.



Traditional seperation in underfloor heating 20 cm

As a rule, with BEKA ceiling heating a supply temperature of around 30°C is sufficient to heat the room adequately. Traditional underfloor heating always requires 40°C or more, depending on the separation and the type of floor covering. BEKA ceiling heating "saves" on the supply temperature and therefore produces more efficient results when energy efficiency is compared with that of traditional underfloor heating.

4. Economic comparison

Economic comparison of BEKA ceiling heating and conventional underfloor heating falls into the following:

- Financial effect on energy input costs depending on the energy efficiency of the two heating technologies;
- Comparison of investment costs incurred in new buildings and retrofitted buildings;
- Profitability over the operational life of the system;
- Additional benefit.

A heating system always consists of several components. The energy efficiency of the whole system is determined by the heat generator extracting the energy required by the system from the energy source by providing additional energy (exergy), and the heat transmitter that releases the heat into the room. The price per unit for the energy source and the consumption of the energy source during operation on the one hand, and the investment costs of the complete system on the other hand, provide information about economic efficiency. A precise comparison of this type can – understandably – only be made in relation to a specific project, owing to the complexity of the special cost factors.

Yet a heating system with a brine/water heat pump is a useful example for comparing BEKA ceiling heating with traditional underfloor heating, with a result that can be considered a tendency. Just the reduction of the supply temperature by more than 10°C in the case of BEKA ceiling heating improves the COP of the heat pump by around 0.9 to 5.3 as compared with traditional underfloor heating. Heat pump electricity costs are therefore reduced by about 40%.

The potential cost savings can still be markedly improved by a heating system with an energetically optimised energy mix. A combination of solar heat, storage technology and a heat pump or other heating technology, possibly with hybrid operation, can be presented here only as an outline for pioneering approaches. It would be foolish to put a figure on the actual rise in economic efficiency because of the complex influences of the individual components.

BEKA ceiling heating is always installed along with ceiling construction. For clear separation of costs, the costs of ceiling construction must be calculated in proportion to the amount invested in the ceiling heating. The thin capillary tubes can be accommodated in practically any ceiling construction. In a plaster ceiling, for example, a plaster layer only 10 to 15 mm thick is enough to cover the capillary tubes completely. That is also the minimum thickness for plaster, and it is independent of the capillary tube technology, so there are no additional costs for the plaster ceiling. In new buildings, but also in retrofitting projects, the cost mix can minimize the investment in an innovative heating technology. The costs of the capillary tube technology itself and installation of the mats are more or less equal to the normal costs of traditional underfloor heating with labour-intensive installation of heating tubes laid close together. The heating engineer will have to charge around 65.00 EUR/m^2 for materials and installation for the capillary tube technology. This price can of course only serve as a rough guide for estimating the costs, since ultimately the actual costs can only be calculated for each specific project.

BEKA capillary tube mats are designed to have a service life of more than 50 years. With top quality installation, the heating surface will fulfil its function "for a lifetime" with minimal servicing. Looking ahead to the trends in energy prices, it is easy for the owner to decide to invest in an innovative and promising heating system, because it is simple to demonstrate the economic efficiency of the system over time. Not least because, in general, heating technology in buildings is always present for a long time, so it is especially important to base the decision on energy efficiency as the prime criterion. On the other hand, a decision in favour of a heating technology based on rapid amortisation will tend to be disadvantageous over the system's operating period of 30 years or more.

BEKA ceiling heating can also be used very efficiently to cool rooms in summer. This additional benefit becomes increasingly attractive in the summer months with users' growing demands regarding thermal comfort. For cooling, cold water (16°C is sufficient) can simply be made available using a reversible heat pump. Simple control technology reliably prevents condensation on the surface of the ceiling. Cooling from the ceiling is very pleasant. The cooling ceiling functions many times more effectively than cooling through the floor. It is silent and also far more energy-efficient than an air flow cooling system.

5. *The advantages of BEKA ceiling heating*

- Low heating-energy consumption due to low supply temperature – around 30°C
- Low construction profile – smallest loss of room height
- Suitable for modernisation projects and new buildings
- Fully suitable for heat pump technology
- Fully suitable for solar energy
- Heating system reacts rapidly
- Suitable for energy-saving cooling
- Creates healthy and pleasant ambient conditions
- Corrosion-free system – high level of system safety
- Service life of more than 50 years
- Low service costs
- 100% recyclable materials – no pollutants.