# Guide on energy savings from ceiling-mounted heating and cooling systems

zehnder

**Save energy using radiant heat.** Energy is precious. As resources become more and more scarce, awareness of this important issue is growing. What is more, the magnitude of energy is also indicated by the constant, inexorable price rises.

Energy costs are also playing an ever-increasingly important role in trade and industry – ideas for lowering these fixed business costs are more in demand. Ceiling-mounted heating and cooling systems offer a practical and efficient solution.

Using the principle of radiant heat, radiant ceiling systems heat and cool buildings in a manner that is both cosy and efficient. They can be used in any room up to 30 m high, from production halls, warehouses, schools, hospitals and offices to exhibition rooms and showrooms. Individually manufactured and tailored to the requirements of each property, ceiling-mounted heating and cooling systems can make a significant contribution to lowering a company's energy costs. This brochure tells you how.

# Energy efficiency

Whether for residential buildings, offices or business rooms or industrial or sports halls, the heat transfer system used influences not only the well-being of the space but also the freedom to design the space and its energy consumption; it is independent from heat generation and heat distribution. On the one hand, the task of heating surfaces is to distribute the heat generated as quickly and evenly as possible throughout the room, and on the other hand the heating and cooling system must be able to react quickly to changes in the load of heating and cooling required.

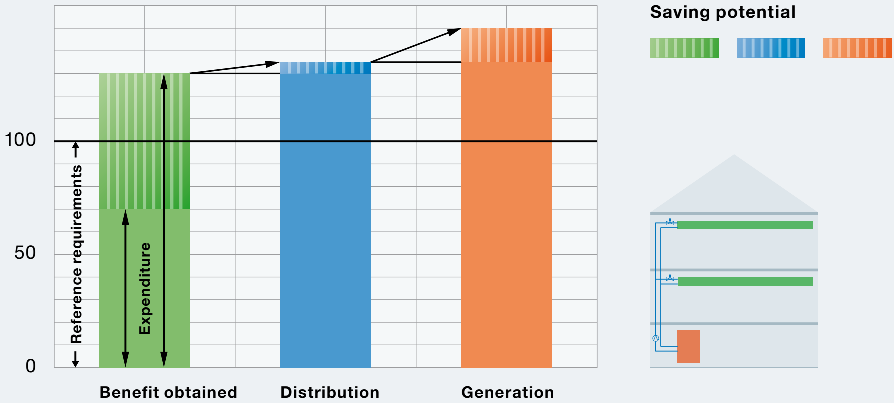
## Energy saving potential

The heat transfer system used largely determines the benefit that will be gained from it. That is, heat should where possible be transferred in such a way that it can be used in the right place at exactly the right time. In other words:

**The main energy saving potential when heating and cooling a building lies in making the correct choice of heat transfer system.**

## Factors affecting the energy efficiency of a heat transfer system

The heat transfer system essentially determines the comfort level and energy savings in a building. How and in what manner energy savings of over 40 % can be achieved is set out over the following pages.




Expenditure and saving potential in terms of benefit obtained, distribution and generation for a building
Source: Prof. a. D. Dr.-Ing. Heinz Bach

**1**

**Human temperature perception**

**2**

**Heat distribution up to ceiling height**

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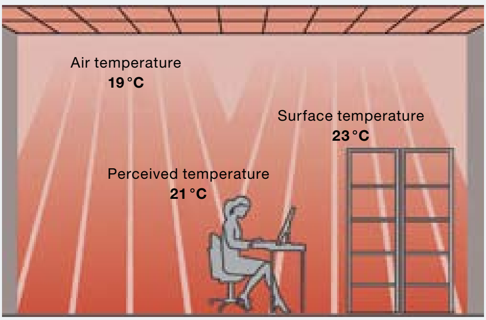
**System temperatures**

# 1

## Human temperature perception

Human perception of temperature is the arithmetic mean of the indoor air temperature and the surface temperature, e.g. of the walls, ceiling and floor.

Due to the radiation and hence the higher surface temperature of ceiling-mounted cooling and heating systems, the indoor air temperature during heating can therefore be kept lower, can be higher during cooling, and still be perceived as pleasant. Energy costs are reduced, both when heating and when cooling, due to the lower or higher air temperature.




Thanks to the higher surface temperature, a much lower air temperature is sufficient for a ceiling-mounted radiant heating system in order to give people a sense of comfortable warmth.

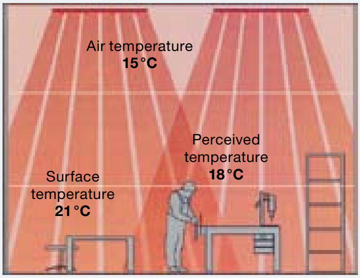
# 2

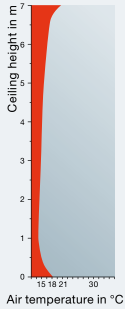
## Heat distribution up to ceiling height

Whereas, with air heating systems the heated air rises, radiant ceiling panels generate heat where the heat radiation comes into contact with objects (walls, floors and people). This results in an even temperature distribution throughout the entire room at ceiling level, and thus a considerably lower energy consumption.

Although the perceived temperature remains the same, the actual indoor air temperature can be up to 3 K lower (for heating) or higher (for cooling). The consequential smaller difference between indoor air temperature and outdoor temperature means that heat loss is dramatically reduced.

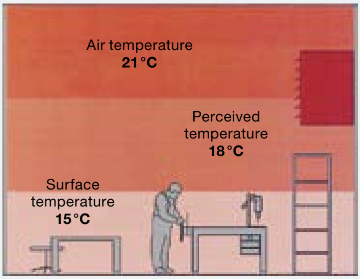
### With radiant ceiling panels

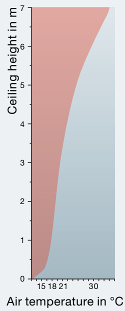


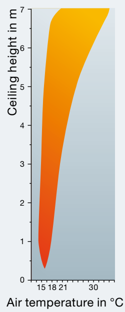

Temperature profile
Radiant ceiling panels

### With air heating systems




Temperature profile
Air heating system




Energy saving
potential

# 3

## Reaction time and controllability

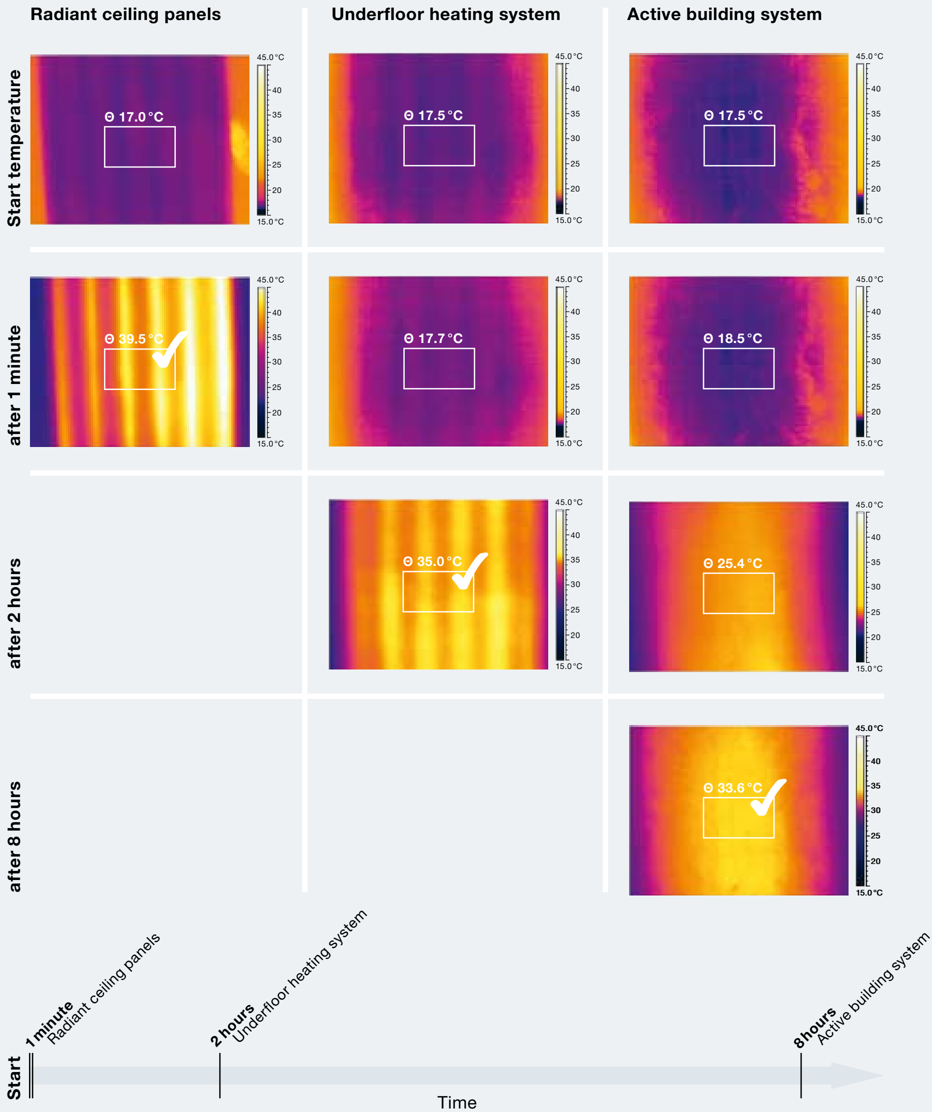
Buildings are becoming increasingly well insulated and thus need less and less energy. Even small variations in the heat load can result in major temperature fluctuations. The result is that users manually intervene in the system and remove the excess heat from the room, e.g. via ventilation.

**The conclusion** from this is that systems are required that can react quickly to changes in the heat load or temperature fluctuations in a room – systems with a rapid reaction time and a very good controllability.

### Test series

To simulate the miscellaneous inertias of various systems, tests were carried out using a radiant ceiling panel, an underfloor heating system and an active building system. All systems were cooled to a surface temperature of 17 °C. The systems were then subjected to the same mass flow and the same flow temperature until each system had achieved a surface temperature of approx. 35 °C.

**Example:** A conference room is heated to 20 °C in the winter. The participants enter the room and give off body heat. This, plus additional heat loads from lighting, projectors, computers etc., makes the temperature of the room rise. The result is that in order to quickly bring the sharply increased room temperature back down to the desired 20 °C, the windows are opened – and precious energy is wasted.




**Result:** the radiant ceiling panel achieved the desired surface temperature within only 1 minute, and thus displayed the fastest reaction time and capacity for self-regulation to cope with temperature fluctuations.

4

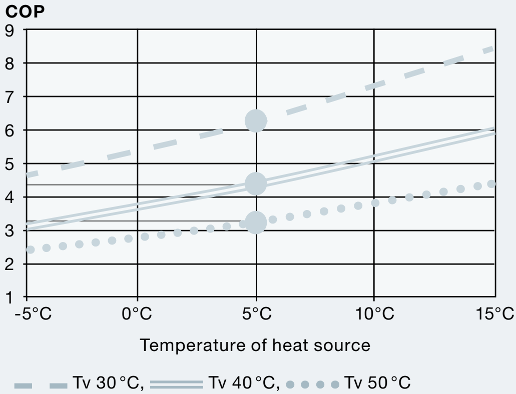
## System temperatures

The future of heating is in the low-temperature field. These systems use less energy, and the energy that they do use is used very efficiently.

Heat transfer systems that work using radiant heat and have a low storage mass are ideally suited to low-temperature systems. Zehnder ceiling-mounted heating and cooling systems are a perfect example of this.

Requiring very low flow temperatures is important, especially when pumping heat. For example, if you use a heat transfer system that runs at a flow temperature of 50 °C, you will use around 90 % more energy than with a system that runs at a flow temperature of 30 °C.

| | $COP_{real}$ | Energy expenditure |
|---|---|---|
| Probe 5 °C/Heating 30 °C | 6.4 | 100 % |
| Probe 5 °C/Heating 40 °C | 4.5 | 140 % |
| Probe 5 °C/Heating 50 °C | 3.4 | 190 % |




**COP** = **C**oefficient **O**f **P**erformance
The COP indicates the relationship between the heat output (kW) generated by the heating network and the recorded electrical output of the heat pump (kW).

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**with Zehnder ceiling-mounted heating and cooling systems**

# Sample calculations

The energy saving potential of over 40 % can be demonstrated and determined more precisely in accordance with DIN V 18599.

As an example we will use a comparison between radiant ceiling panels and air heaters.

### Boundary conditions

Hall height 20 m, room temperature regulation for both systems via PI regulators, air distribution at a normal induction ratio, lateral air outlet

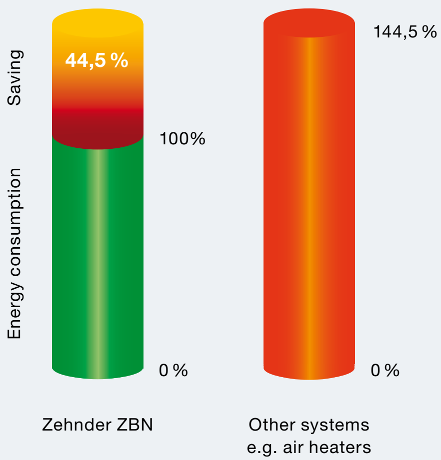
| | $f_{hydr}$ | $f_{int}$ | $f_{Radiant}$ | $\eta_L$ | $\eta_C$ | $\eta_B$ |
|---|---|---|---|---|---|---|
| Zehnder ZBN | 1,00 | 1,00 | 0,85 | 0,89 | 0,97 | 1,00 |
| Air heating system | 1,00 | 1,00 | 1,00 | 0,63 | 0,97 | 1,00 |

### Basic information

Calculation formula under DIN V 18599

$$\eta_{h,ce} = \frac{1}{4 - (\eta_L + \eta_C + \eta_B)} \qquad Q_{h,ce,mth} = \left[\frac{f_{Radiant} \cdot f_{int} \cdot f_{hydr}}{\eta_{h,ce}} - 1\right] Q_{h,mth}$$

$Q_{h,ce,mth}$ additional monthly expenditure of heat transfer, in kWh/mth
$Q_{h,mth}$ monthly heat required, in kWh/mth
$f_{hydr}$ hydraulic balancing factor
$f_{int}$ intermittent operation factor
$f_{Radiant}$ factor for effect of radiance
$\eta_{h,ce}$ overall efficiency of heat transfer in room
$\eta_L$ partial efficiency for vertical air temperature profile
$\eta_C$ partial efficiency for room temperature regulation
$\eta_B$ partial efficiency for specific losses from external structures



## Energy consumption with radiant ceiling panels

$$\eta_{h,ce} = \frac{1}{4 - (\eta_L + \eta_C + \eta_B)} \qquad Q_{h,ce,mth} = \left[\frac{f_{Radiant} \cdot f_{int} \cdot f_{hydr}}{\eta_{h,ce}} - 1\right] Q_{h,mth}$$

$$\eta_{h,ce} = \frac{1}{4 - (0{,}89 + 0{,}97 + 1)} = 0{,}877$$

$$Q_{h,ce,mth} = \left[\frac{1 \cdot 1 \cdot 0{,}85}{0{,}877} - 1\right] Q_{h,mth} = \underline{-0{,}031\ Q_{h,mth}}$$

$$Q_{h,ce,mth} = -0{,}031\ Q_{h,mth} = -0{,}031 \cdot 10000 = \underline{-310\ \text{kWh}}$$

10 000 kWh - 310 kWh = 9690 kWh -> **100 %**

## Energy consumption with air heaters

$$\eta_{h,ce} = \frac{1}{4 - (\eta_L + \eta_C + \eta_B)} \qquad Q_{h,ce,mth} = \left[\frac{f_{Radiant} \cdot f_{int} \cdot f_{hydr}}{\eta_{h,ce}} - 1\right] Q_{h,mth}$$

$$\eta_{h,ce} = \frac{1}{4 - (0{,}63 + 0{,}97 + 1)} = 0{,}714$$

$$Q_{h,ce,mth} = \left[\frac{1 \cdot 1 \cdot 1}{0{,}714} - 1\right] Q_{h,mth} = \underline{0{,}4\ Q_{h,mth}}$$

$$Q_{h,ce,mth} = -0{,}4\ Q_{h,mth} = -0{,}4 \cdot 10000 = \underline{4000\ \text{kWh}}$$

10 000 kWh + 4 000 kWh = 14 000 kWh

$$\frac{14\,000 \cdot 100\,\%}{9690} = \mathbf{144{,}5\,\%}$$

**Result**

Energy saving with Zehnder radiant ceiling panels 44.5 %

# Products

Zehnder radiant ceiling panel systems can be used in practically all larger rooms of heights up to 30 m. Thanks to their rapid reaction time and their optimal heat distribution, they operate exceptionally efficiently.

## **zehnder** *zbn*

- Blends in with the architecture – available in a range of colours
- Optimal heat distribution tailored to the room geometry – 7 standard widths and special widths available
- Wide range of special solutions: angled panels, perforated panels for sound absorption, panels with holes for light fittings, ball deflector grids, raised top pieces, etc.
- Longer individual components (up to 7.5 m) mean up to 20 % lower installation costs

## **zehnder** *zip*

- Special solutions: Ball deflector grids for sports halls
- Particularly easy to install owing to its light weight, which makes it perfect for refurbishment
- Simple to install – the modules attach via a press/screw fitting
- Easy to store and quick to deliver thanks to its standardised components
- Corrosion protection: special finishes available for damp rooms

## **zehnder** *carboline*

- Optimal controllability, short reaction time
- Flush appearance – blends in aesthetically with architecture
- Easy to fit to both new and existing grid and suspended ceilings
- Perforated finish provides noise insulation
- Long lifespan thanks to corrosion-resistant materials
- Antibacterial

## **zehnder** *como*

- Available in a range of colours
- Range of models: grids, sails, covered ceilings, invisible under plasterboard – fits the architecture
- Special solutions such as cut-outs for light fittings or projectors
- Noise absorption through perforated surface
- Long lifespan thanks to corrosion-resistant materials

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