# Global Cost study for different HVAC solutions in hotels

## Comparative assessment of radiant heating and cooling solutions versus fan coil units

- ☑ **Global Cost savings of up to 59% after 15 years with Uponor radiant heating and cooling solutions**
- ☑ **Up to 42% reduction in $CO_2$ compared to conventional fan coil units**

**Proven: Hotel operators can significantly improve the profitability of their business with Uponor.**

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# Abbreviations

**BES** Building Energy Simulation
**CAV** Constant Air Volume
**FCU** Fan Coil Unit
**HVAC** Heating, Ventilation and Air Conditioning
**IAQ** Indoor Air Quality
**TABS** Thermally Activated Building System

# 1. Executive summary

Historically construction costs have often been given higher priority than running costs when making an investment decision. A rethink has been taking place based on increasing awareness of energy efficiency and sustainable building operation. Thus Global Cost considerations are gaining importance in the system selection process for HVAC systems.

Astute investors are increasingly focusing their attention not only on the costs of construction, but also on the future running costs of their buildings. In addition to the investment cost, operating costs and costs of repair and replacement for HVAC equipment plays an important role. Global Cost become an important instrument to assess the initial and running costs of building during a defined period of time. The analysis enables a review of the trade-off made between higher investments and lower running costs in the utilisation phase.

This study compares the Global Cost of equipping a hotel building with four different types of heating and cooling solutions. Three different radiant heating and cooling solutions have been analysed and compared in this study with conventional air conditioning via fan coil unit (FCU). A mechanical fresh air ventilation system (CAV) with heat recovery was used to provide the same indoor air quality (IAQ) in all compared cases.

Uponor's radiant heating and cooling solutions comprise of a water-based heating and cooling system based on the heat radiation principle with heated or chilled surfaces. Whereas a FCU system is a pure air based heating and cooling solution that heats or cools the air within a room.

Fan coils units are considered to be the traditional system for air conditioning in hotels today. The disadvantages of fan coil systems are high operation and maintenance costs as well as noise generation and uncomfortable drafts leading to lower guest satisfaction. The analysis shows that the innovative Uponor systems have lower operation and maintenance costs, resulting in lower Global Cost of up to 59% while increasing guest satisfaction.

### A rethink is on its way

Although radiant heating and cooling systems represent a proven and established technology in Europe – due to energy savings and lower running costs when compared to air-based technologies like FCUs – there is still limited evidence of the adoption within the hotel segment. This will change in the future due to the increased corporate social responsibility of hotel chains and the increased comfort expectations of hotel guests.

The advantages for hoteliers are **better cost efficiency, lower energy consumption, greater sustainability and profit.**

# Key savings

**21%**

lower initial investment costs

**42%**

$CO_2$ emission reduction

**59%**

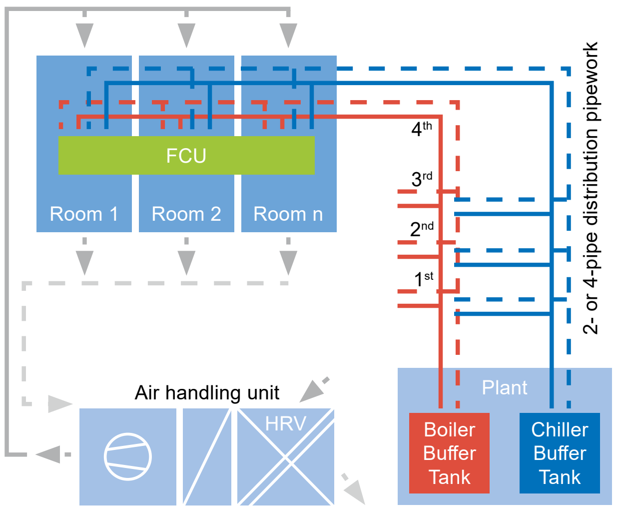
lower Global Cost if the remaining value of the installed system is also considered

**56%**

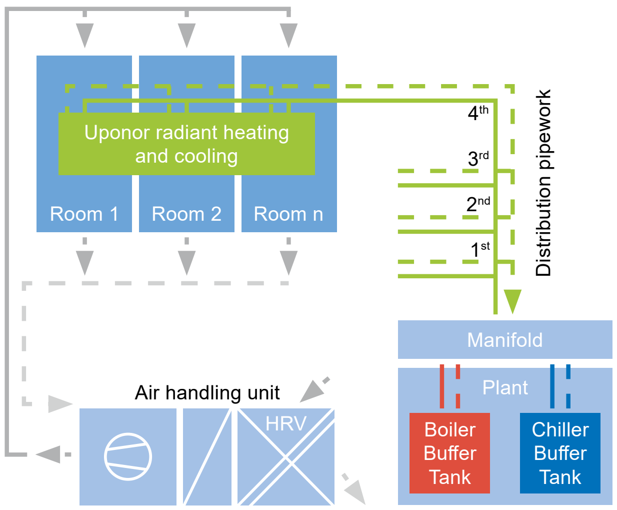
lower annual running costs

# 2. Details of a simulated hotel building

## HVAC scheme with FCU




## HVAC scheme with Uponor radiant heating and cooling




### Background details

| | |
|---|---|
| **Location** | Munich, Germany |
| **Number of guest rooms** | 100 |
| **Size of average hotel room** | 19 m² |

### Set points and internal loads

| | |
|---|---|
| **Room temperature range when occupied** | 21°C–25.5°C |
| **Equipment loads** | 13 W/m² |
| **Room occupation hours*** | 3 p.m.–8 a.m. |

### Ventilation system

| | |
|---|---|
| **Mechanical fresh air ventilation volume (CAV)** | 10 l/s/m² |
| **Air exchange rate** | 1.33 |
| **Supply air temperature** | 16ºC |

### Building shell and core

| | |
|---|---|
| **External wall** | U-value 0.24 W/m²K |
| **External window glazing** | U-value 1.1 W/m²K, g-value 0.48 |
| **External solar shading** | no |

* Applies to CAV, occupants and equipment load schedules

# 3. System comparison

A traditional air-based FCU system was compared to three types of radiant heating and cooling systems. The radiant systems differ in terms of:

- **installation method (suspended ceiling or structurally integrated in concrete)**
- **thermal output**
- **price**
- **expected lifespan**

A mechanical fresh air ventilation system with heat recovery was used to provide the same indoor air quality (IAQ) in all compared cases. A standard, default control algorithm was applied to the fan coil, assuming that it is only turned on when the room is occupied.

Energy generation was considered via a gas condensing boiler for heating and a central chiller for cooling for all scenarios.

The mechanical fresh air ventilation system provides an **identical indoor air quality** in the compared systems.

## Overview of compared heating and cooling systems

| | Fan coil unit (FCU) | Uponor Thermatop M | Uponor Renovis | Uponor Contec ON |
|---|---|---|---|---|
| **Heat source** | Boiler | | | |
| **Heat sink** | Central chiller | | | |
| **Ventilation** | Mechanical fresh air ventilation with heat recovery | | | |
| **Guest room units – description** | AC fan coil for cooling and heating supplemented by ventilation with heat recovery | Seamless suspended heating/cooling ceiling supplemented by ventilation with heat recovery | | Structural Contec ON heating/cooling ceiling (surface-near) supplemented by ventilation with heat recovery |
| **Capacity range – heating** | 1.4–8.0 kW | 103 W/m² | 59 W/m² | 30–50 W/m² |
| **Capacity range – cooling** | 1.5–8.0 kW | 65 W/m² | 49 W/m² | 40–70 W/m² |
| **Design flexibility** | + | +++ | ++ | ++ |
| **Renovation** | + | + | ++ | n.a. |
| **Sound emission** | 20–70 dB(A)** (** Maximum value accord. DIN EN 15251) | 0 dB(A) | 0 dB(A) | 0 dB(A) |
| **Sound absorption** | - | Class C up to αW = 0.65 | - | - |
| **Use of renewable energy** | - Low cooling and high heating supply water temperatures | + High cooling and low heating supply water temperatures | + High cooling and low heating supply water temperatures | + High cooling and low heating supply water temperatures |
| **Thermal comfort** | - Draughts | +++ Fast reaction time, comfortable radiant heating and cooling, no draughts | ++ Comfortable radiant heating and cooling, no draughts | ++ Comfortable radiant heating and cooling, no draughts |
| **Maintenance** | Filter change every 6 months; condensate pipework cleaning every 6 months. | No maintenance | No maintenance | No maintenance |
| **Response time** | ++ | ++ | ++ | ++ |
| **Temperature Control** | Single-room or central control | Single-room control | Single-room control | Single-room or central control |
| **Lifespan (years)** | 12 | 30 | 30 | 60 |

# 4. Calculation method

The Global Cost assessment was carried out in accordance with the comparative methodology of EU Regulation No. 244/2012 for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements. The building model used for the calculation of energy consumption was created using the validated dynamic simulation software IDA ICE 4.8.

### Global Cost evaluation method

The Energy Performance of Buildings Directive (EPBD Directive 2010/31/EU) requires the European Commission to establish a comparative methodology of the EU Regulation No. 244/2012[ii] for calculating cost-optimal levels for the minimum energy performance requirements of buildings and building elements. The Global Cost calculation is undertaken in accordance with this method in terms of Global Cost for a 15-year calculation period.

### Climate load profile for Munich

The building energy simulation (BES) modelling employed the building envelope characteristics and internal/external climate load profiles that are typical for the city of Munich, Germany.

Local and central plants (HVAC system) were sized based on the cooling/heating loads and ventilation rates from BES modelling, using the same method in the course of completing a mechanical scheme design.

Global Cost for building and building elements are calculated by summing up initial investment and running costs. When calculating the running costs, a discount rate for each year is applied, and the residual value, to reflect the remaining value of the investment, is also considered, as can be seen below:

$$C_g(\tau) = C_I + \sum_j \left[ \sum_{i=1}^{\tau} \left( C_{a,i}(j) \times R_d(i) \right) - V_{f,\tau}(j) \right]$$

where:

- $\tau$ means the **calculation period**
- $C_g(\tau)$ means the **Global Cost** (referred to starting year $\tau_0$) over the calculation period
- $C_I$ means the **initial investment costs** for measure or set of measures j
- $C_{a,i}(j)$ means the **annual running costs** during year i for measure or set of measures j
- $R_d(i)$ means the **discount rate** for year i
- $V_{f,\tau}(j)$ means the **residual value** of one or a set of measures j **at the end of the calculation period** (referred to the starting year $\tau_0$), to be determined by a straight-line depreciation of the initial investment until the end of the calculation period and referred to the beginning of the calculation period.

The stipulations of the European Union were **the basis for the Global Cost evaluation method.**

# 5. Cost overview

The method of Global Cost ensures an overall consideration of all costs and values across the life cycle of the considered period of time. Its goal is to give a guidance for the selection and investment into the most economic systems and solutions. The Global Cost comprises the following cost categories.

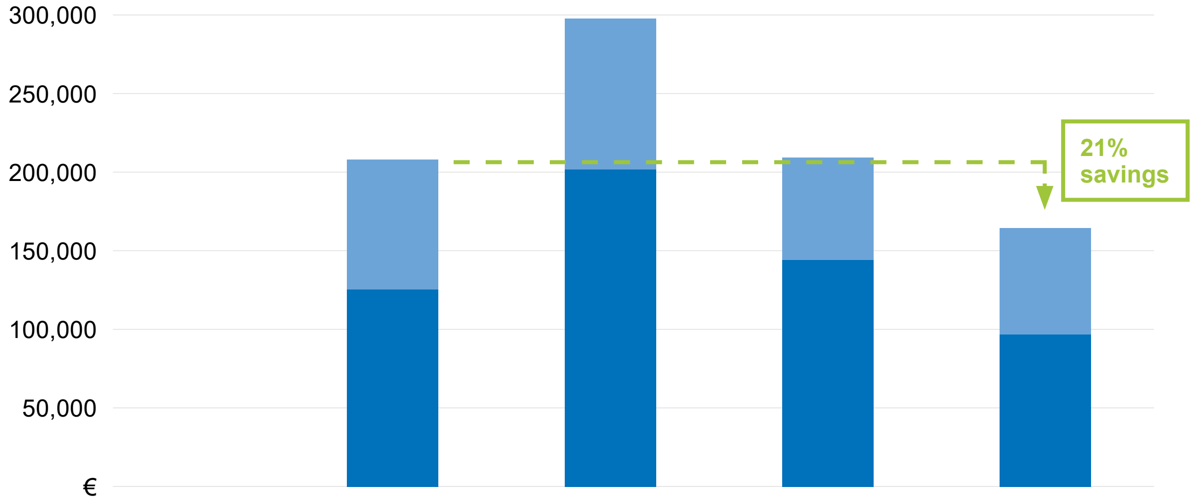
## 5.1 Initial investment costs $C_I$

The initial investment costs are often a crucial decision criterion, and significant differences can be seen when comparing different systems. Investment costs consist of product costs and installation costs. The investment costs as considered in this assessment are customary in the industry, and the country considered. Based on the selected hotel building located in Munich, the cost level for Germany has been applied.

When selecting a new system, **the Global Cost shall be the main basis** for the decision.

**Compared to FCU, Contec ON is the most economical solution for a new building with up to 21% lower initial investment costs.**

**Initial investment costs $C_I$***




| | FCU | Thermatop M | Renovis | Contec ON |
|---|---|---|---|---|
| **Installation** | 84,000 | 95,004 | 66,500 | 70,000 |
| **Material total costs** | 125,000 | 202,400 | 142,400 | 94,400 |

* Initial investment costs of the selected systems for a 100-room hotel with $\tau = 1$


21%
lower initial investment costs

## 5.2 Annual running costs $C_{a,i}(j)$

The annual running costs $C_{a,i}(j)$ in the Global Cost calculation consist of maintenance, energy and reinvestment costs for equipment that needs to be renewed within the period of consideration.

With energy-efficient radiant heating and cooling systems, energy consumption can be reduced significantly. In hotel rooms, the demand for cooling is generally much higher than the demand for heating; this makes cooling a very important area for generating savings – especially against the background of the rising temperature level during the summer months, also in Central Europe.

In the assessment, the energy consumption figures exclude energy used for the mechanical, minimum constant fresh air ventilation, which is the same for all compared variants.

The primary energy factors for gas has been considered with 1.1 and for electricity with 1.8.

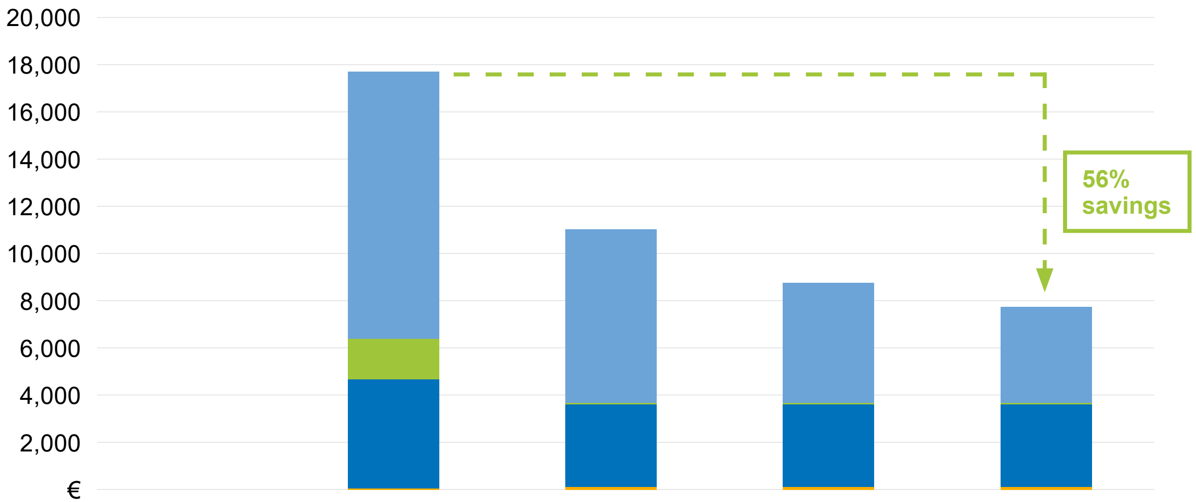
For the purpose of this study, the gas and electricity prices are based on their prices in June 2019 in Munich, Germany, which were €0.045/kWh and €0.19/kWh respectively.

Annual price increase for energy has been considered with 3%.

**Uponor solutions ensure up to 56% lower annual running costs compared to the conventional FCU.**

**FCUs generate up to three times higher maintenance costs compared to Contec ON due to higher maintenance and spare parts efforts.**

**Annual running costs $C_{a,i}(j)$***




| | FCU | Thermatop M | Renovis | Contec ON |
|---|---|---|---|---|
| **Maintenance costs** | 11,495 | 7,435 | 5,223 | 4,110 |
| **HVAC aux costs** (electricity for fans and pumps) | 1,436 | 53 | 53 | 53 |
| **Cooling costs** (electricity) | 4,628 | 3,458 | 3,458 | 3,511 |
| **Heating costs** (gas) | 67 | 112 | 112 | 134 |

* Annual running costs of the selected systems for a 100-room hotel with τ = 1

**56%**

lower annual running costs

Maintenance costs are assumed to be 5.5% of the investment costs for traditional (air-based cooling) systems like FCU. These are of a higher complexity, require refrigerant checks and include wear parts like air filters, fans and bearings, which requires continuous maintenance and replacement. According to field experience, the maintenance costs of water-based radiant systems amount to 2.5% of the investment costs, based on lower complex systems and less wear parts.

Compared to radiant heating and cooling systems, where the energy is transfer in a water circuit driven by a pump, fan coil units heat or cool the space with heated or chilled air driven by a fan. Based on the lower thermal capacity of air compared to water, these systems require more auxiliary energy to operate the fans in order to transfer the same amount of heating and cooling energy into the room. This is one important difference of FCU, compared to radiant systems that explains the higher additional auxiliary energy demand (HVAC aux).

With energy-efficient radiant heating and cooling systems, **annual running costs can be reduced significantly with up to 56%** compared to FCU.

# 42%

$CO_2$ emission reduction

### COP of the chiller at 3.5

The difference in cooling energy consumption for FCU is due to the individual efficiency of cooling energy generation using different cooling supply water temperatures for FCU and radiant cooling systems. Lower supply water temperatures for FCU result in a lower chiller COP of 2.6, whereas higher supply water temperatures for radiant cooling systems result in a higher chiller COP of 3.5. So the efficiency of the chiller can be increased significantly with ca. 35% using radiant cooling.

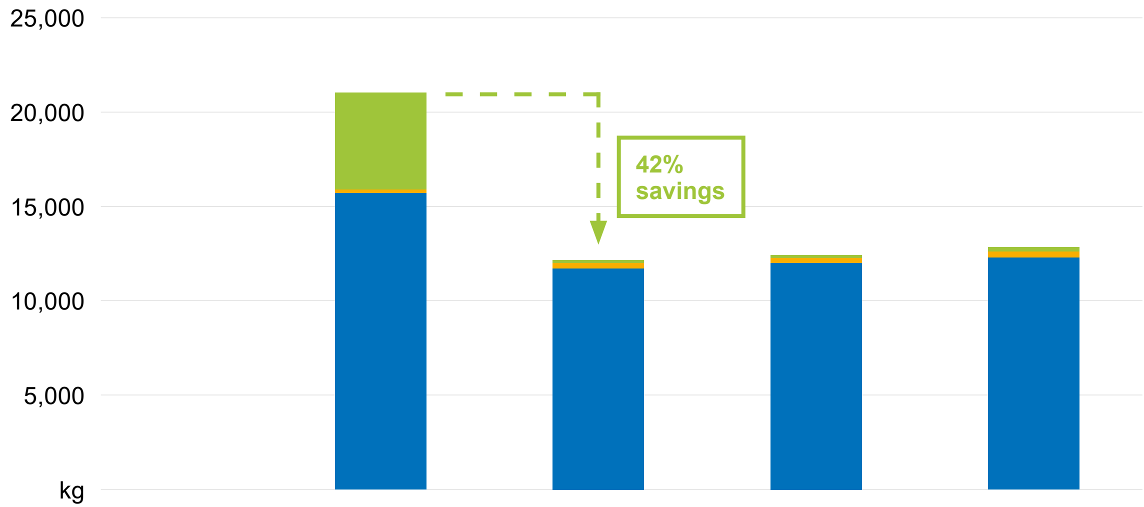
The slight differences in the cooling energy used for radiant systems (Thermatop M, Renovis, Contec ON) are due to more accurate thermal control properties with systems with a lower thermal capacity like Thermatop M and Renovis. These systems can be adjusted more accurately, and that is why slightly less energy is required.

The slight differences in heating energy across the systems are due to the different thermal capacities, which follows the explanation of cooling energy use. FCU systems only heat up air with low thermal capacity compared to gypsum radiant ceilings (Thermatop M and Renovis) and TABS (Contec ON).

Uponor radiant ceilings are future-proof due to their **compatibility with any energy sources,** especially renewable energies.

**Uponor radiant ceilings achieve up to 42% $CO_2$ emission reduction compared to FCU.**

**$CO_2$ emission in (kg/a)***




| | FCU | Thermatop M | Renovis | Contec ON |
|---|---|---|---|---|
| **Cooling** | 4,908 | 111 | 120 | 192 |
| **Heating** | 169 | 281 | 281 | 338 |
| **HVAC aux** | 15,834 | 11,830 | 11,830 | 12,012 |

* $CO_2$ emission of the selected systems for a 100-room hotel with $\tau = 1$
The $CO_2$ emissions for gas and electricity are 0.201 and 0.65 kg/kWh respectively

## 5.3 Discount rate $R_d(i)$

Discount rate $R_d(i)$ is a discount factor for year i based on the discount rate r to be calculated:

$$R_d(p) = \left(\frac{1}{1+r/100}\right)^p$$

where p means the number of years from the start of operation of the hotel building and r means the real discount rate. The countries determine the discount rate to be used in the financial calculation after having performed a sensitivity analysis on at least two different rates of their choice. For the present hotel building located in Munich, the discount rate as defined by the German central bank (Deutsche Bundesbank) was used with r = 1.94% p.a. over the considered calculation period of 15 years. This resulted in a discount rate of $R_d(p) = 0.74$.

## 5.4 Residual value $V_{f,\tau}(j)$

The residual value $V_{f,\tau}(j)$ is determined by a straight line depreciation of the initial investment until the end of the calculation period and referred to the beginning of the calculation period. The longer the lifespan of a component or a system, the more the advantage and the lower the Global Cost. For structural radiant systems like Contec ON, which feature a lifespan of 60 years or more (the same as a building), this fact creates a substantial advantage compared to components with a shorter lifespan like FCU with a lifespan of 12 years.

When considering the Global Cost, the lifespan of the selected system is an important criteria that reflects the time for reinvestment.

The expected lifespan of each item was selected according to EN 15459[iii] and VDI 2067 Part 1[iv].

**The main components of the Uponor radiant heating and cooling solutions last up to five times longer than FCU – 60 versus 12 years according to EN 15459iv – while all other equipment components as risers, radiant controls and HVAC equipment are expected to last for the same length of time.**

Uponor radiant systems such as Contec ON **with a lifespan of 60 years and more** offer a clear cost advantage.

### Expected lifespan of equipment*

| | FCU | Thermatop M | Renovis | Contec ON |
|---|---|---|---|---|
| **Room unit/emitter with manifold** | 12 | 30 | 30 | 60 |
| **Risers, distribution pipework** | 40 | 40 | 40 | 40 |
| **Electrical instal. radiant controls** | 30 | 30 | 30 | 30 |
| **Plant HVAC equipment** | 20 | 20 | 20 | 20 |

* Expected lifespan of equipment in years
* EN 15459[iv], VDI 2067 Part 1[iv]

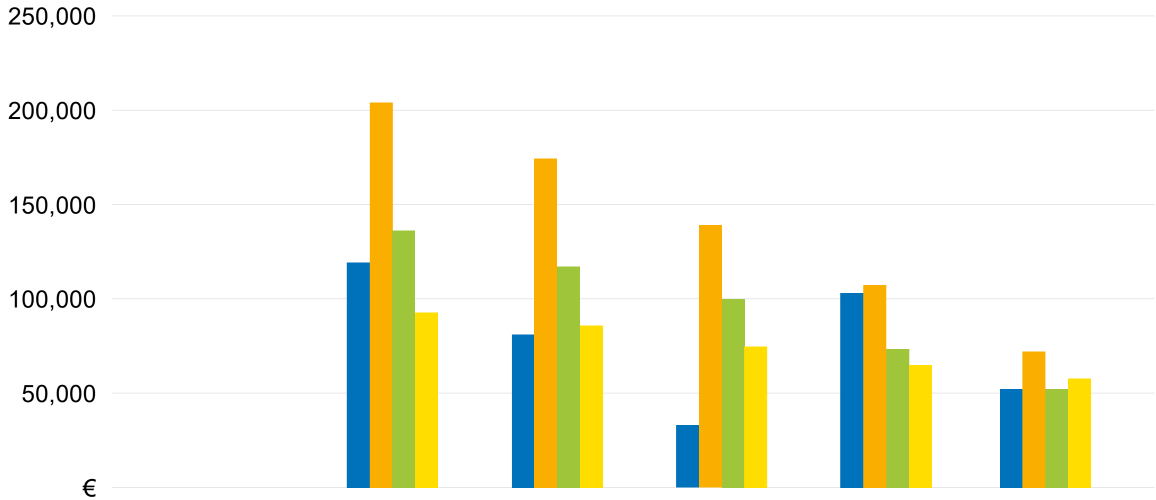
## Residual value of selected systems for a hotel building with 100 rooms

The chart shows the difference in residual value of the compared systems depending on the years of the building's operation. Thermatop M represent the highest residual value across the full life cycle, which is driven by the higher investment but also by the long lifetime and thus lower depreciation. FCU residual values reduce fast due to the short lifetime and the high depreciation, resulting in a reinvestment need after 12 years that is increasing the residual value after 12 years.

In general, it can be stated that the residual value of Uponor radiant heating and cooling solutions remains high based on the long lifetime of these systems.

**Thermatop M has the highest residual value, thereby proving its extraordinary durability.**

### Residual value*




| Years of operation | 1 | 5 | 10 | 15 | 20 |
|---|---|---|---|---|---|
| FCU | 125,000 | 83,333 | 31,250 | 104,160 | 52,080 |
| Thermatop M | 202,400 | 175,413 | 141,680 | 107,947 | 74,213 |
| Renovis | 142,400 | 123,413 | 99,680 | 75,947 | 52,213 |
| Contec ON | 94,400 | 86,613 | 76,880 | 67,147 | 57,413 |

* Residual value of the selected systems for a 100-room hotel

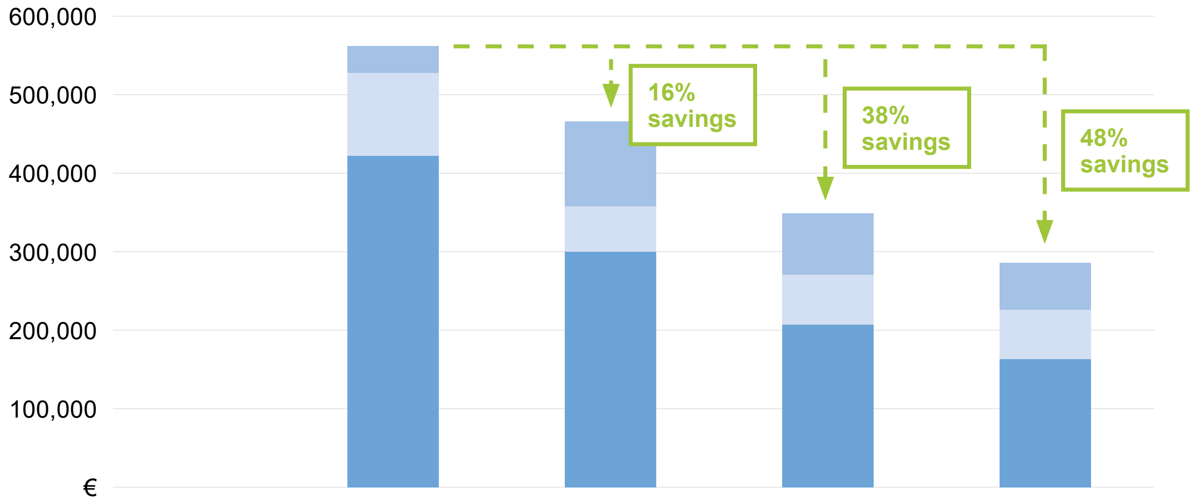
# 6. Global Cost

The Global Cost calculation method as stated in 4.1 considers two perspectives in one approach. The cost perspective is considered with investment, operation and maintenance costs, as well as the value development for the considered system investment.

The first approach reflects the incurred expenses for the heating and cooling system of a hotel building and its operation for a defined period of time. In the case of this hotel building with 100 rooms, the analysis shows a clear financial advantage of the Uponor radiant systems with up to 48% lower costs than the conventional FCU after 15 years of operation. The FCU solution shows the highest total costs due to its short service life, mechanical complexity and high running costs in the form of energy and maintenance costs.

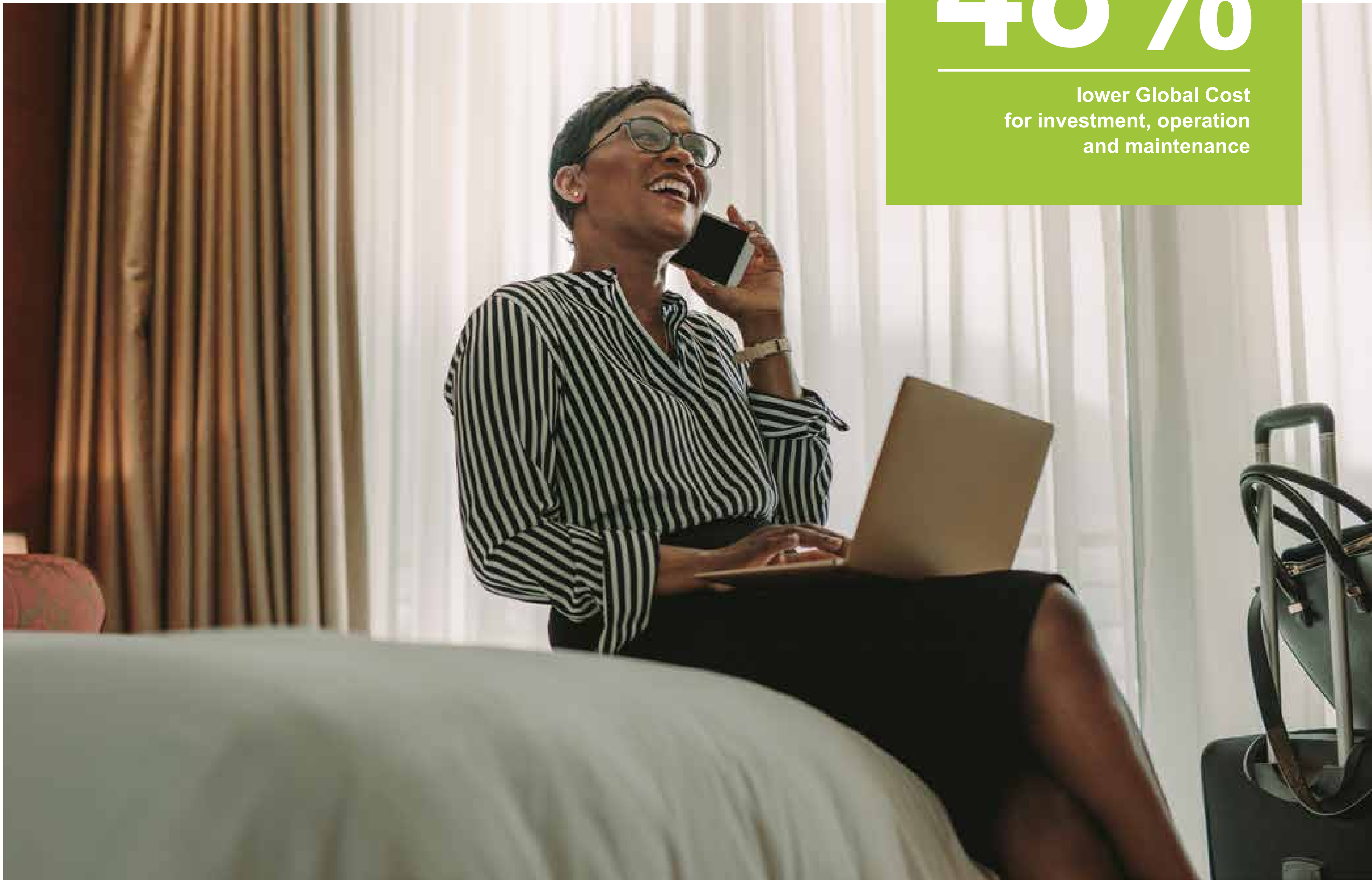
**In a comparison of Global Cost, the Uponor solutions perform significantly better than the FCU.**

## Cost comparison*




| | FCU | Thermatop M | Renovis | Contec ON |
|---|---|---|---|---|
| Investment costs | 418,000 | 297,404 | 208,900 | 164,400 |
| Operation costs | 109,092 | 63,159 | 63,159 | 64,116 |
| Maintenance costs | 34,496 | 111,527 | 78,338 | 61,650 |
| Total | **561,588** | **472,089** | **350,396** | **290,166** |

* Cost comparison after 15 years of operation assuming a mean energy price escalation rate of 3%



# 48%

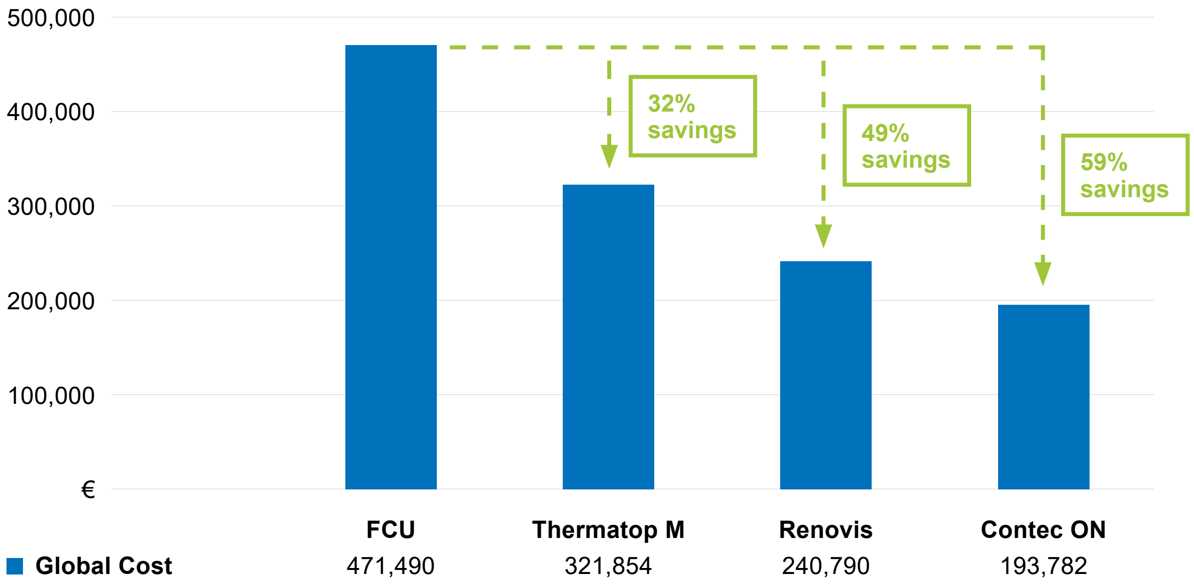
**lower Global Cost for investment, operation and maintenance**

The second perspective includes the overall value development of the systems during the considered operation time including residual value of the investment. The Global Cost of the different systems were calculated according to the methodology of the EU Regulation No. 244/2012[ii] as stated in 4.

It clearly reflects the financial advantage of the Uponor radiant heating and cooling systems for hotel buildings with up to 59% lower Global Cost already after 15 years of operation. The main reasons for high Global Cost of the FCU are the required reinvestment after 13 years, the higher energy consumption and its higher maintenance costs.

**Uponor solutions ensure up to 59% lower Global Cost compared to the conventional FCU after 15 years.**

## Global Cost $C_g(\tau)$*



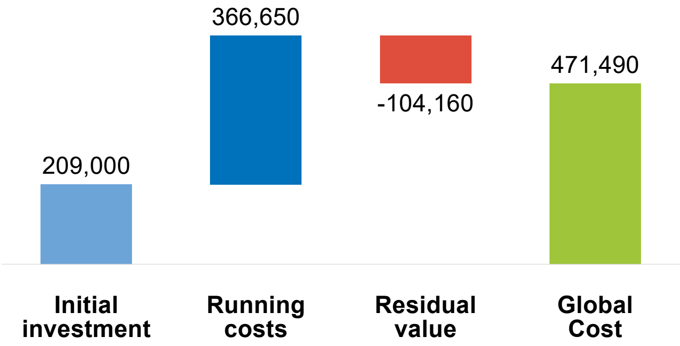

* Global Cost after 15 years of operation assuming a mean energy price escalation rate of 3% with $\tau$ = 15

# 59%

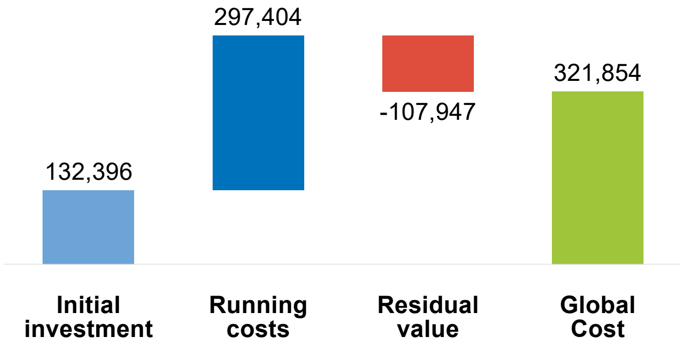
**lower Global Cost if the remaining value of the installed system is also considered**

## Split of costs and the impact on the Global Cost*

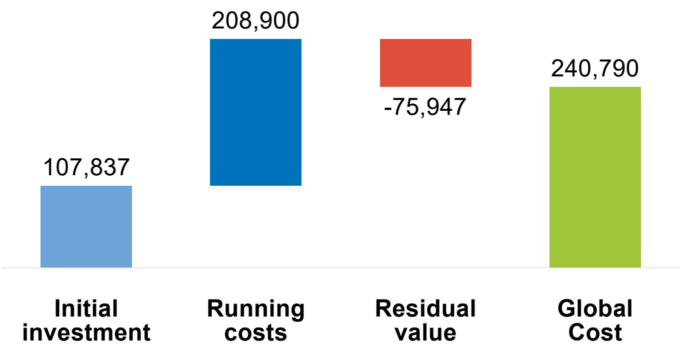
### FCU



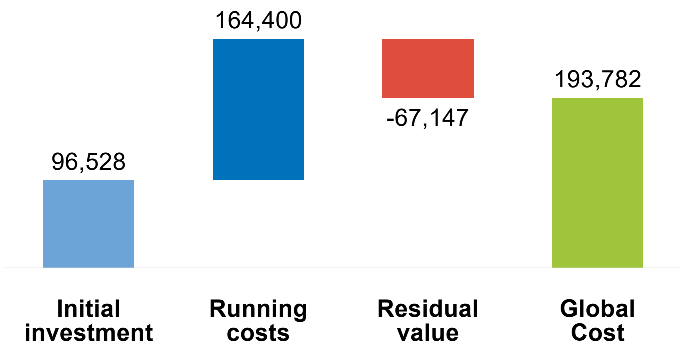

### Thermatop M




### Renovis




### Contec ON




* After 15 years of operation

# 7. Conclusion

This study examines the full life cycle costs of different heating and cooling systems based on a hotel with 100 guest rooms located in Munich, Germany. The energy performance of the building is simulated using a dynamic thermal building simulation tool (IDA ICE 4.8[i]) and the Global Cost evaluation uses the methodology of EU Regulation No. 244/2012[ii] for calculating cost-optimal levels to meet the minimum energy performance requirements for buildings and building elements.

The HVAC systems in this study are based on a traditional air conditioning system with conventional fan coil units (FCU), which was compared to the performance of three different Uponor radiant heating and cooling ceiling systems. The latter were either suspended or structurally integrated in the concrete.

**Radiant ceiling solutions offset the higher investment costs** and boost net cash flow on account of savings in day-to-day use.

The results have proven that radiant heating and cooling systems from Uponor help to significantly decrease the overall Global Cost for buildings compared to traditional HVAC schemes using FCU. The evaluation shows that Uponor radiant heating and cooling systems provide investment and operation cost savings of up to 48%. Additionally, it could be demonstrated that the Global Cost savings with the Uponor solutions are up to 59% if the remaining value of the installed system is also considered.

### A larger investment is worth it

In conclusion, the Uponor radiant heating and cooling ceiling solutions have proven to be cost-effective for a hotel building despite higher investment costs in the construction phase. The resulting future savings in the operating phase compensate for the initial costs and thus increase the net cash flow during the whole life cycle of the hotel building.

Apart from the financial aspects, the image factor cannot be ignored. Hoteliers who focus on sustainability and make a contribution to climate protection can improve their reputation among guests. Ecological aspects in particular are becoming increasingly important in travel planning.

**Methodology:** The energy performance of buildings and building elements was calculated EU-compliantly.

**Result:** Uponor radiant heating and cooling systems provide Global Cost savings up to 59%.

# 8. The Uponor products featured in the study

### Uponor Thermatop M

The suspended radiant heating and cooling ceiling system Thermatop M is an exceptionally easy-to-install heating and cooling ceiling for residential and commercial properties. The system consists of diffusion-resistant multilayer composite pipe (MLCP) and comprises standardised modules that can be quickly mounted on conventional ceiling substructures – without the need for any additional tools – thanks to a clip-in design. The panelling can then be fitted completely independently by the drywall contractor, thus preventing any overlap between trades.

The specially designed fixing rails ensure excellent contact between the pipes and the plasterboard thermal panel, thus facilitating the outstanding performance of the cooling system. Thanks to straightforward planning and design, specialist installers can create seamless, non-directional and architecturally appealing heating and cooling ceilings for a wide spectrum of properties, from detached homes through to large commercial buildings.

Benefits:

- **Lightweight, prefabricated heating/cooling elements in multilayer composite pipe with flexible module lengths**
- **Simple clip-in installation in standard ceiling substructures**
- **No overlap between heating and drywall trades**

**Very Simple:** The ceiling-mounted cooling system Thermatop M is exceptionally easy to install.

### Uponor Renovis

The Uponor Renovis drywall system comprises a 15 mm thick plasterboard panel in which high-grade Uponor piping has been pre-installed at the factory. Using a substructure of conventional 27/60 CD profiles, the elements can be mounted as drywall panels on pretty much all wall substrates. Therefore, there is no need for complex demolition work, meaning that existing properties can be renovated whilst still in use. Once the joints have been filled in and sanded, work can simply continue on the Renovis elements.

Renovis makes it possible to regulate the temperature via radiant heating and cooling – including in individual rooms – and facilitates integration within an existing high-temperature system with radiators. In turn, this enables individual adjustment in line with usage requirements – without needing to replace the entire heating and cooling system. This reduces costs and permits considerable design freedom when renovating individual rooms. Connecting the system using a simple Tichelmann distribution unit also makes life easier for installers when it comes to arranging the heating circuits, control unit and installation.

Benefits:

- **The pipe fixing elements fasten the pipe to the installation**
- **Integration of ventilation, light sources or other electrical devices is possible**
- **Installation possible on all wall and ceiling surfaces**
- **Room comfort provided at a low temperature of the heating system**

**Ideal for existing properties:** With the Renovis drywall system, existing buildings can be renovated whilst still in use.

### Uponor Contec ON

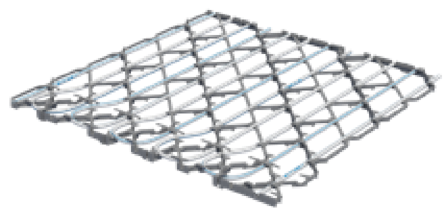
Concrete components such as concrete ceilings can be used for the cost-effective heating/cooling of multi-storey buildings.

The Contec ON system, which is fitted close to the concrete ceiling surface, represents the ideal solution in areas with higher heating/cooling needs, such as hotel rooms. The special Uponor Contec ON plastic pipe support enables precise pipe heights just a few millimetres above the ceiling underside and, at the same time, maintains distance to the lower reinforcement.

Benefits:

- **Optimum solution in terms of offsetting peak loads and regulating the temperature of individual rooms/zones**
- **Fast reaction times and excellent controllability**
- **Rapid construction progress**

**The optimal addition:** The Contec ON system, fitted close to the surface, is the ideal addition in areas with higher heating/cooling needs.



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# Source

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