KNOWLEDGE

ENERGY EFFICIENT COOLING

Increasing the water flow temperature

BARCOL-AIR
by Swegon

Feel good inside

Introduction

One major advantage of high capacity area cooling systems is that they allow rooms to be cooled at relatively high cold water flow temperatures. High flow temperatures enable a large proportion of the cooling energy to be drawn directly from the outdoor air, with the result that very little – or even no – electrical energy is needed for cooling generation.

Various innovations in the field of radiant ceilings now make it possible to have even higher water flow temperatures for cooling applications. This consequently improves the efficiency of refrigeration units and in some cases even allows total independence on refrigeration units thanks to free cooling.

Energy efficiency and the sustainable management of buildings is a key consideration in building design. Operating radiant ceilings energy efficiently naturally brings cost advantages but in addition to that, legislators in certain countries, such as Switzerland[1]), are requiring systems to be ever more energy efficient before building cooling is permitted at all.

The greater the capacity of a radiant ceiling system, then the higher the cold water flow temperatures during operation can potentially be. Over the years, therefore, energy and operating costs can be saved many times over and the building's ecological footprint significantly improved.

In the case of office buildings, free cooling becomes an economically attractive prospect at cold water flow temperatures starting at 18 °C and should be taken into consideration. Heat absorption systems such as chilled ceilings that work with high cold water flow temperatures are therefore particularly well suited to free cooling.

This document addresses the following questions:

- How are the refrigeration unit, cold water flow temperature and free cooling interrelated?
- How do the selected radiant ceiling sail systems affect the cold water flow temperature?
- What potential for free cooling do high capacity radiant ceiling sail systems offer?

[1] EnG 730.0 / Canton of Zürich: Guidelines for summertime heat protection in new builds and conversions.

Energy efficient cooling

Increasing the cold water flow temperature

August 2024_V2

CONTENTS

Increasing the cold water flow temperature

Author

Thomas Burger

Head of Technology
Climate ceiling systems

Refrigeration unit – heat source and heat sink

For operation, refrigeration units and heat pumps in all cases require both a heat sink to which the refrigeration unit can transfer energy, and a heat source from which the heat pump can absorb energy. Where refrigeration units are concerned, this „environmental energy" is obtained in the vast majority of cases from the outdoor air.

Refrigeration unit and heat pump can always operate in both directions so long as the control system technology makes provision for this.

Procedure:

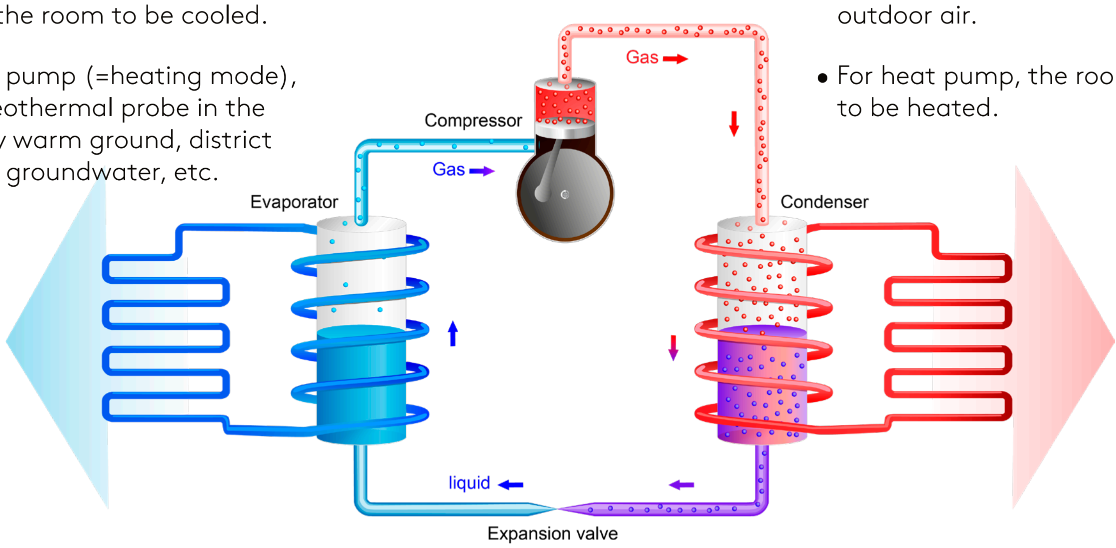
- The compressor compresses a gaseous refrigerant. This increases the temperature of the refrigerant.
- The warm, compressed gas gives off heat energy to the heat sink (usually the outdoor air). This often happens indirectly via a second circuit to the dry cooler.
- The resulting drop in temperature causes the refrigerant to condense. For this to happen, the refrigerant must be warmer than the heat sink.
- The liquid refrigerant then enters an expansion valve where its pressure is reduced. The internal energy drops as a result.
- The liquid refrigerant is now evaporated again through energy absorption from the building's cooling circuit. For this to happen, the refrigerant must be colder than the heat source.

Heat source

- For refrigeration unit (=cooling mode), the room to be cooled.
- For heat pump (=heating mode), e.g. a geothermal probe in the relatively warm ground, district heating, groundwater, etc.

Heat sink

- For refrigeration unit, the outdoor air.
- For heat pump, the room to be heated.



From this, we can conclude that:

- The lower the temperature in the heat sink, the less (electrical) energy the compressor needs to heat the gas to a temperature ABOVE the heat sink temperature.
- If it's possible to have a higher flow temperature in the building's cooling circuit, then the temperature of the gas in the heat circuit does not need to be so low. This also reduces compressor power consumption.
- If the heat sink is colder than the required flow temperature in the building, the compressor doesn't need to operate at all. This is referred to as free cooling. In practice, the outdoor air temperature must be 2 K below the water flow temperature for this to work.

For free cooling, the outdoor air temperature needs to be 2 K below the water flow temperature.

Refrigeration unit – efficiency

The efficiency of a heat pump or refrigeration unit is indicated by the coefficient of performance (COP). Although strictly speaking we use Energy Efficiency Ratio (EER) for refrigeration units and Coefficient of Performance (COP) for heat pumps, the mathematical relationship is the same. The ratio of heating or cooling capacity (Q) to the consumed electrical power (Pel) yields the coefficient of performance (COP), the aim being for this to be as high as possible.

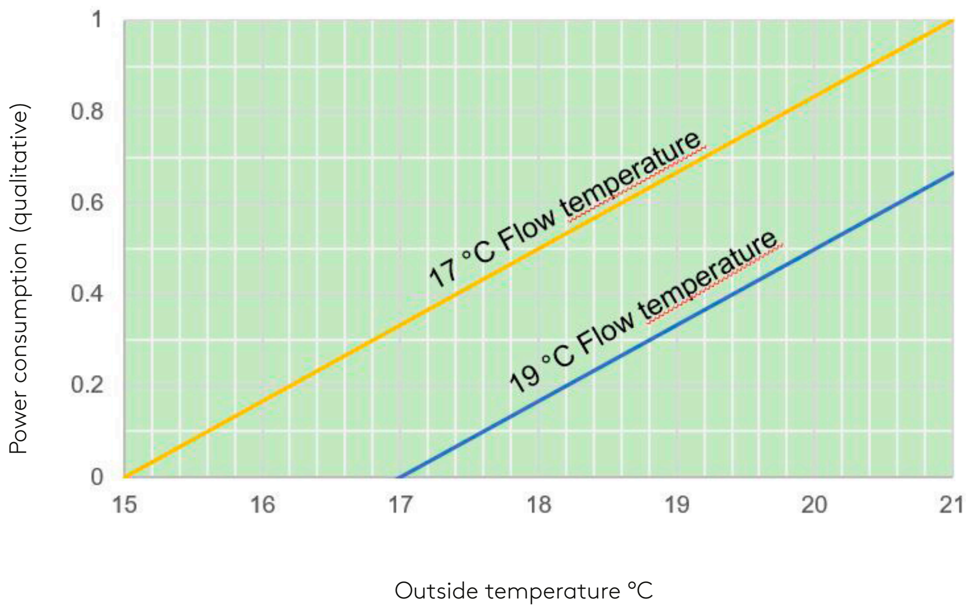
$$COP = \frac{Q}{(P_{el})}$$

As shown on pages 4 and 5, the power consumption (Pel) of the refrigeration unit decreases with decreasing outdoor air temperature and increasing flow temperature of the coolant in the building.

Since we cannot control the outdoor air temperature, the main option for improving the efficiency of a refrigeration unit is to increase the cold water flow temperature.

As soon as the flow temperature is more than 2 K above the outdoor air temperature, the power consumption of the compressor falls to zero and free cooling starts.

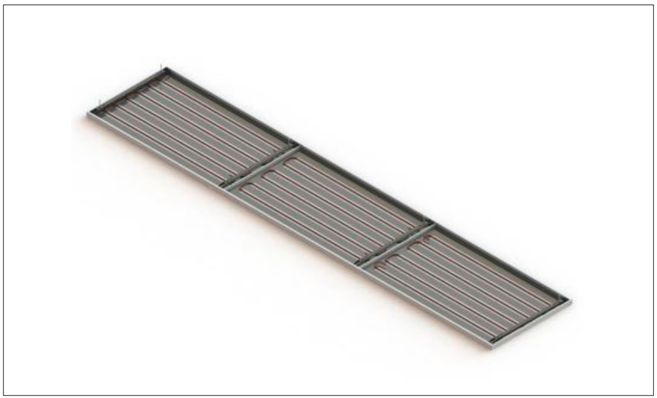
Qualitative relationship between outdoor temperature and
power consumptionfor different flow temperatures



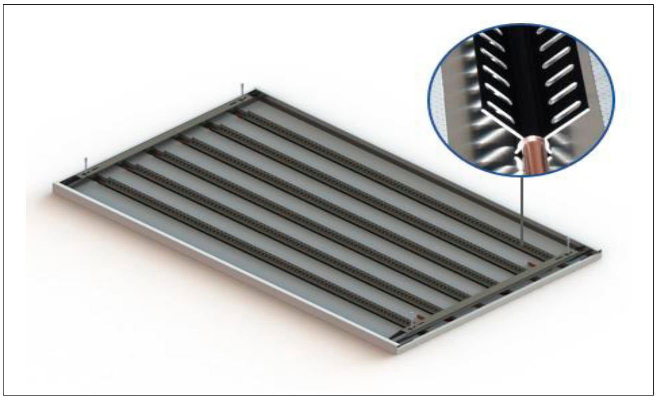
Cold water flow temperature – climate ceiling cails

IThe next section of this White Paper will look at the possibilities for increasing capacity or raising the flow temperature using the climate ceiling sail from Barcol-Air. This modular system enables the conventional heated/chilled sail to be expanded with additional components to create a high capacity sail.

Compared with a conventional heated/chilled sail with the same surface area, a high capacity system such as this can absorb up to 40 % more energy from the environment and operate with a cold water flow temperature up to 2.6 K higher.

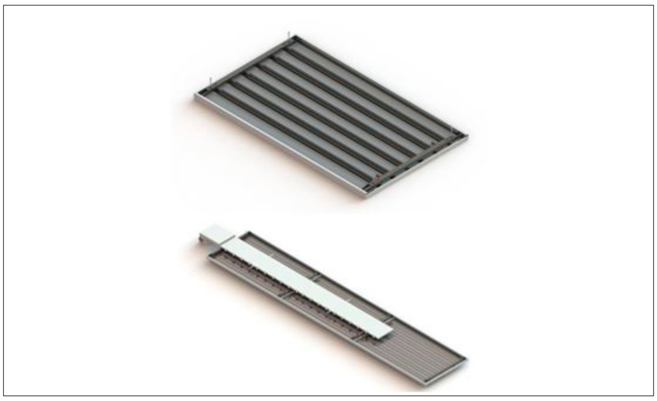


Basic system of heated/chilled sail



Heated/chilled sail + Convector Wings®

Heated/chilled sail + CAURUS



Heated/chilled sail + CAURUS + Convector Wings®

Cold water flow temperature – climate ceiling sails

The following diagram shows how both ceiling coverage and choice of system affect the cold water flow temperature.

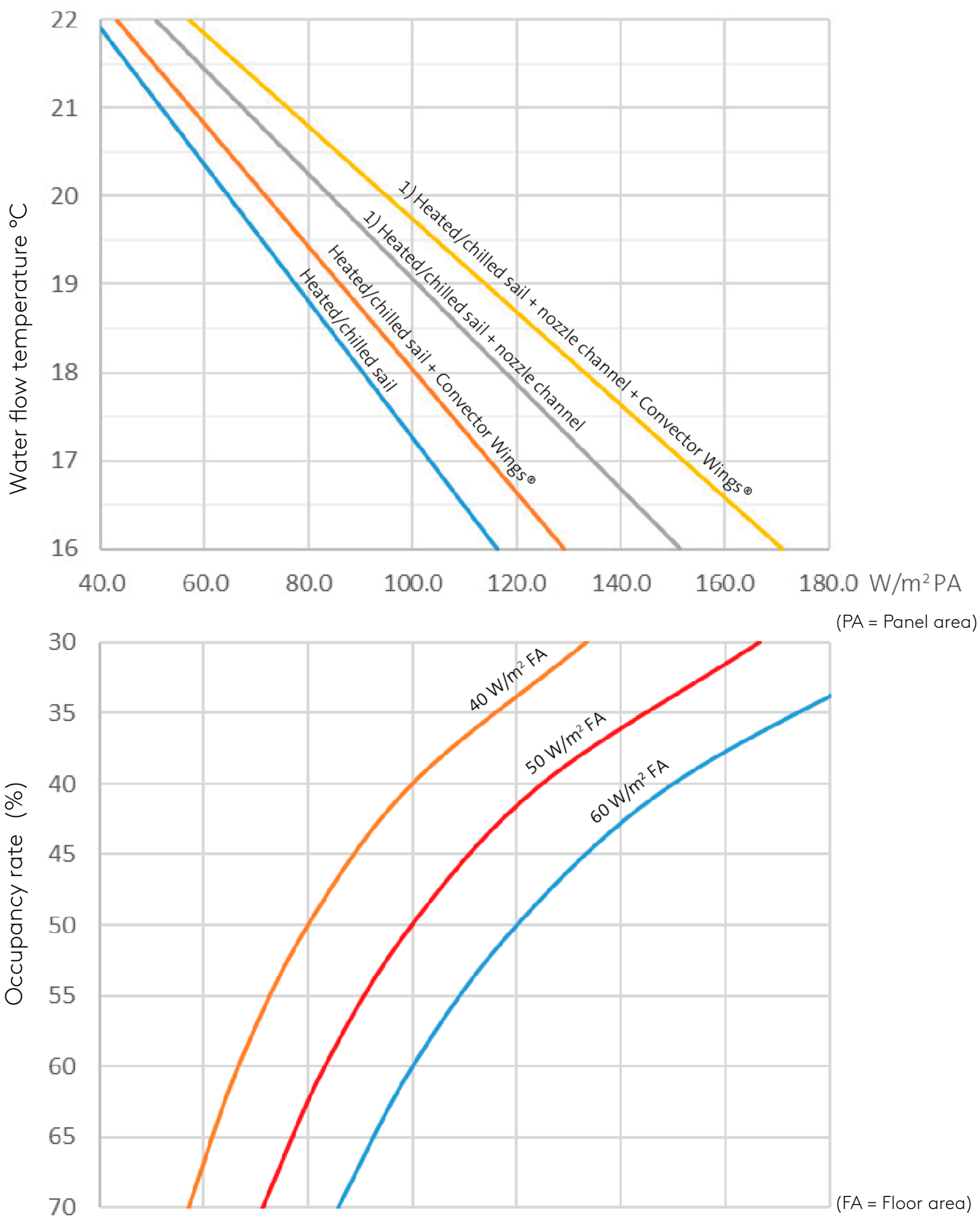
A building's calculated cooling load is usually known – in this example it is 40, 50 and 60 W/m² of floor area (FA). A smaller ceiling coverage necessitates a higher installed capacity per m² of panel area (PA) resulting inevitably in lower flow temperatures.

Result:

With a ceiling coverage of 50 % and a cooling load of 50 W/m² of floor area, a conventional heated/chilled sail would require a flow temperature of 17.2 °C in order to deliver the necessary cooling capacity.

By using the additional components – namely the nozzle channel CAURUS and Convector Wings® – the system can operate with a flow temperature of 19.8 °C, in other words a flow temperature that is 2.6 K higher.

(Data based on measurements carried out at the Barcol-Air climate laboratory.)



[1] Figure takes into account the charge capacity of the concrete core when using a CAURUS or CAURUS and Convector Wings®.

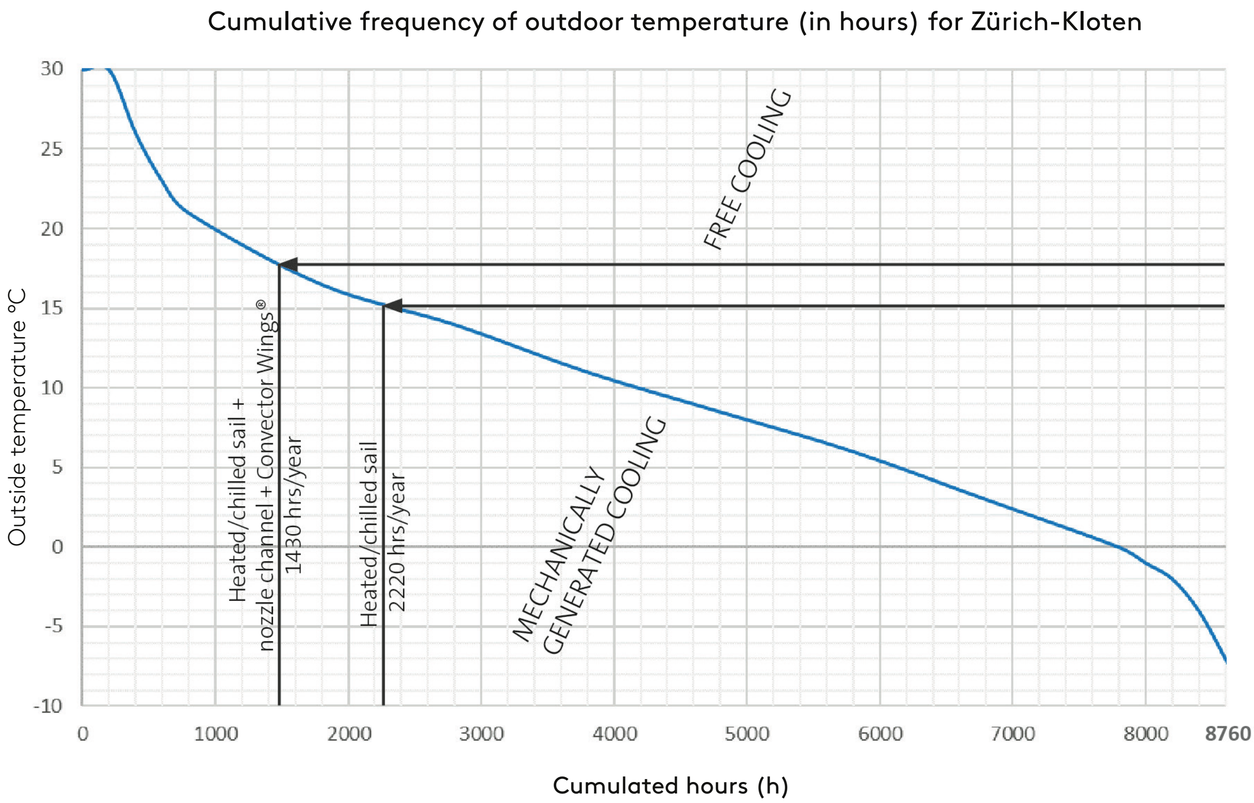
Cold water flow temperature – climate ceiling sails and free cooling

As previously described, a higher capacity climate ceiling system allows higher cold water flow temperatures to be used. With climate ceilings, this always results in a better refrigeration unit COP, as the flow temperature is closer to the outdoor temperature. For free cooling to be possible, the water flow temperature of the refrigeration unit must be 2 K above the outdoor air temperature.

By way of example, the following graph shows the outdoor air temperature in Zürich-Kloten as a cumulative frequency curve.

Result:

For cooling purposes, a heated/chilled sail expanded into a high capacity system with nozzle channel CAURUS and Convector Wings® needs to use electrical energy 40 % less often for cooling. Furthermore, the COP of the refrigeration unit in the remaining 1430 hours is significantly better than with the conventional heated/chilled sails.



Proportion of free cooling as a function of cold water flow temperature

Source: Graph from the Swiss Meteorological Institute (SMA)

Conclusion

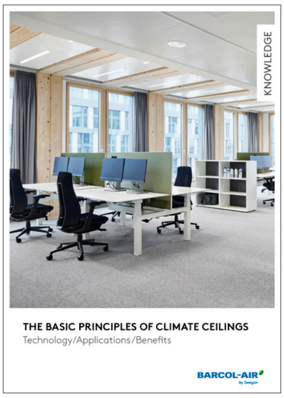
The possibility of increasing the cold water flow temperature should be examined in-depth at the project-specific technical building concept stage, in every climate ceiling project and lastly when selecting the climate ceiling system. This can significantly improve a building's savings potential in terms of electricity demand and ultimately its ecological footprint.

In ideal conditions – with the right choice of system – the refrigeration unit is only used for cooling for a brief period in the year. For the rest of the year, cooling is achieved by means of free cooling.

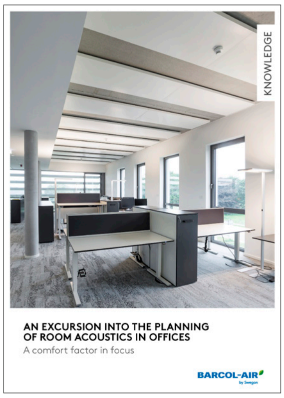
High capacity climate ceiling systems are a worthwhile choice, particularly in view of increasing demands where energy efficiency and costs are concerned.

Other documents with facts and insights

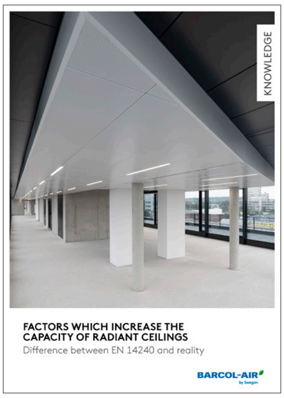
The basic principles of radiant ceilings
Technology/Applications/Benefits



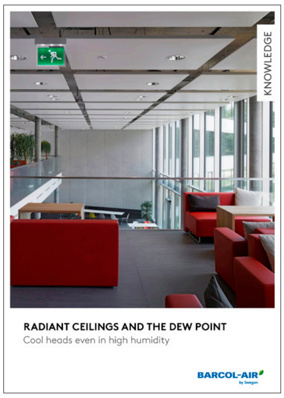
Planning room acoustics in offices
A comfort factor in focus



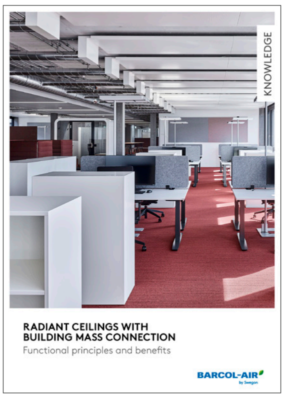
Capacity of radiant ceilings
Difference between EN 14240 and reality



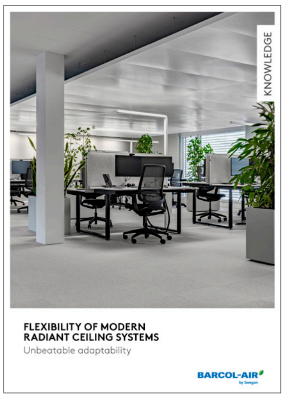
Radiant ceilings and the dew point
Cool heads even in high humidity



Radiant ceilings with building mass connection
Functional principles and benefits



Flexibility of modern radiant ceiling systems
Unbeatable adaptability



Notes

Notes

Contacts

International

Barcol-Air Group AG

Wiesenstrasse 5

8603 Schwerzenbach

T +41 58 219 40 00

F +41 58 218 40 01

info@barcolair.com

barcolair.com

Switzerland

Barcol-Air AG

Wiesenstrasse 5

8603 Schwerzenbach

T +41 58 219 40 00

F +41 58 218 40 01

info@barcolair.com

Barcol-Air AG

Via Bagutti 14

6900 Lugano

T +41 58 219 45 00

F +41 58 219 45 01

ticino@barcolair.com

Germany

Swegon Klimadecken GmbH

Schwarzwaldstrasse 2

64646 Heppenheim

T: +49 6252 7907-0

F: +49 6252 7907-31

klimadecken@swegon.de

swegon.de/klimadecken

France

Barcol-Air France SAS

Parc Saint Christophe

10, avenue de l'Entreprise

95861 Cergy-Pontoise Cedex

T +33 134 24 35 26

F +33 134 24 35 21

france@barcolair.com

barcolair.com

Italy

Barcol-Air Italia S.r.l.

Via Leone XIII n. 14

20145 Milano

T +41 58 219 45 40

F +41 58 219 45 01

italia@barcolair.com

barcolair.com

Feel good **inside**

BARCOL-AIR
by Swegon