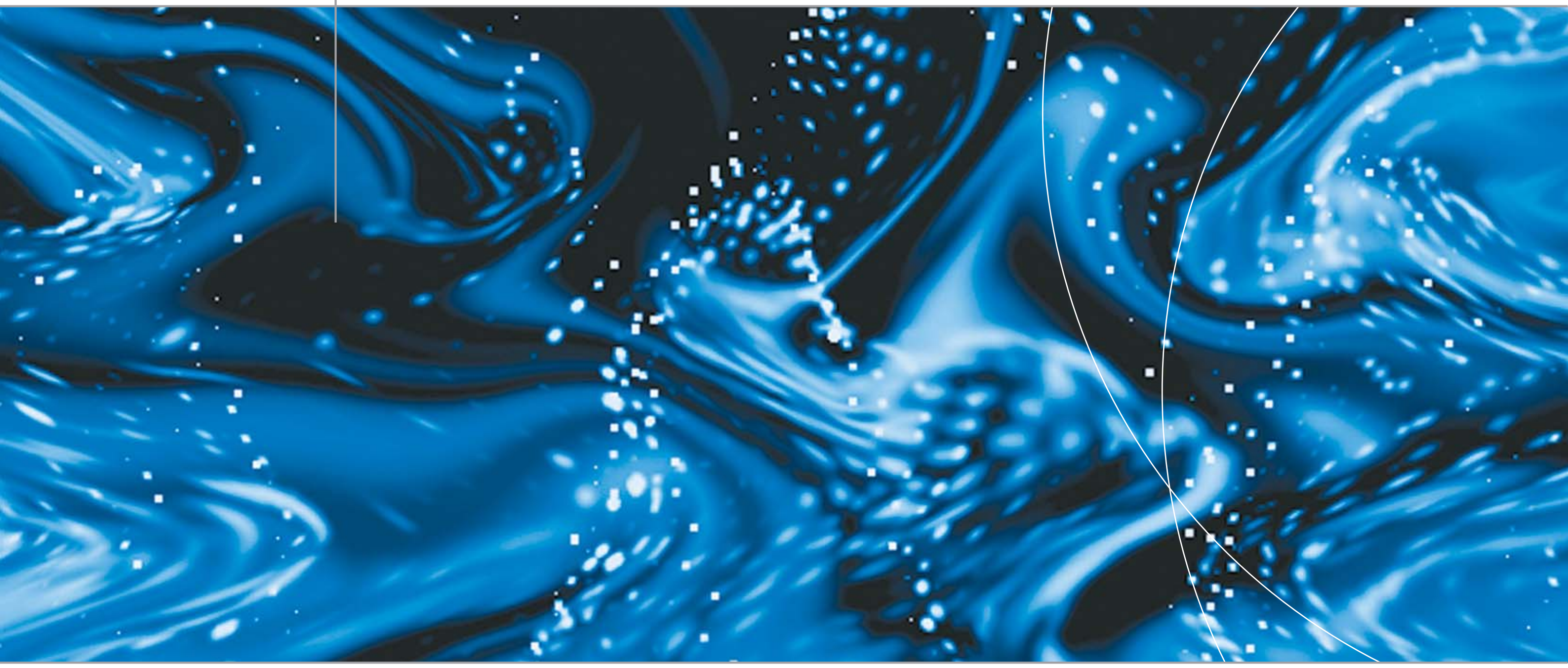
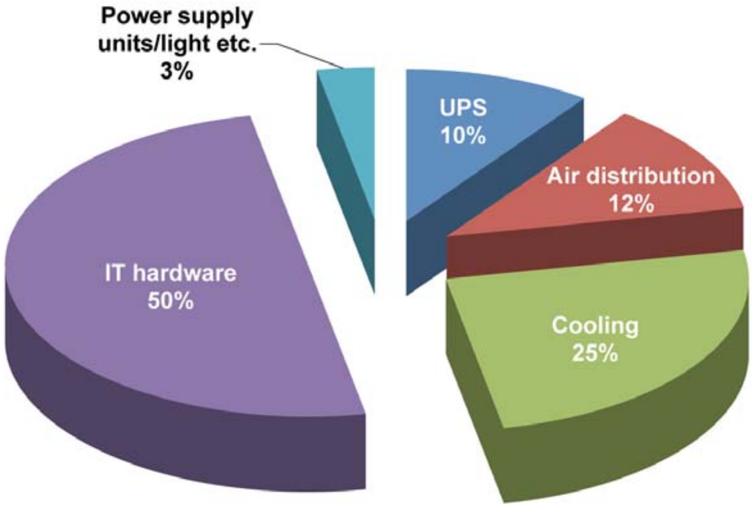
Energy efficient cooling of data centers with hybrid dry coolers



> Engineering a sustainable future

Source: DENA



Green IT – climate change has reached data centers

In view of climate change and ecological challenges, environment-friendly and sustainable IT is a central topic and has been discussed accordingly at the CeBIT 2010.

The aim is to use energy resources more efficiently and to reduce the emission of CO2. Special attention needs to be paid to maximum energy efficiency – i.e. the optimization of energy consumed per performance unit.

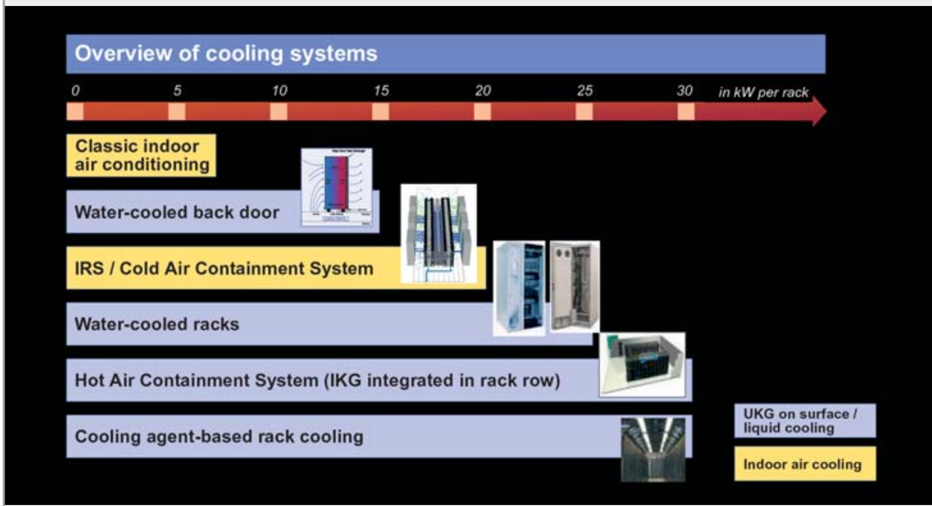
The most important step away from high power consumption and towards a better climate balance is to increase energy efficiency.

Since the power consumption for cooling the server rooms accounts for up to 45% of the overall power consumption, ground-breaking technologies can reduce these costs considerably.

Power consumption in data centers
The above pie chart, from a current DENA (German Energy Agency) study, shows the typical distribution of data center energy consumption.

As shown, the energy consumed for cooling constitutes the second highest percentage and thus must be considered accordingly for renovating existing data centers in order to improve their energy efficiency as well as for planning new data centers.

Source: IBM Site and Facility Services



Green IT – climate change has reached data centers

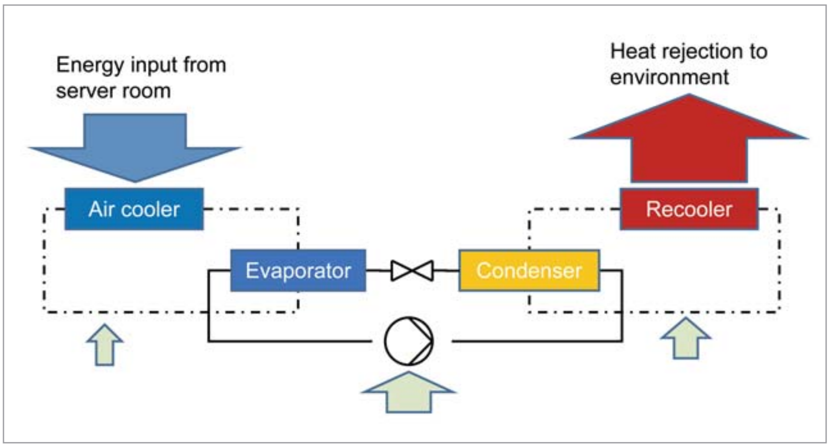
Cooling of data centers
In most cases, the server-rooms are cooled using the classic ambient air cooling method with cold water-recirculation coolers or CRAC units. For higher power densities, water-cooled racks are applied as well.

The cold water is generated by a refrigeration unit (water chiller) that can be air- or water- cooled.

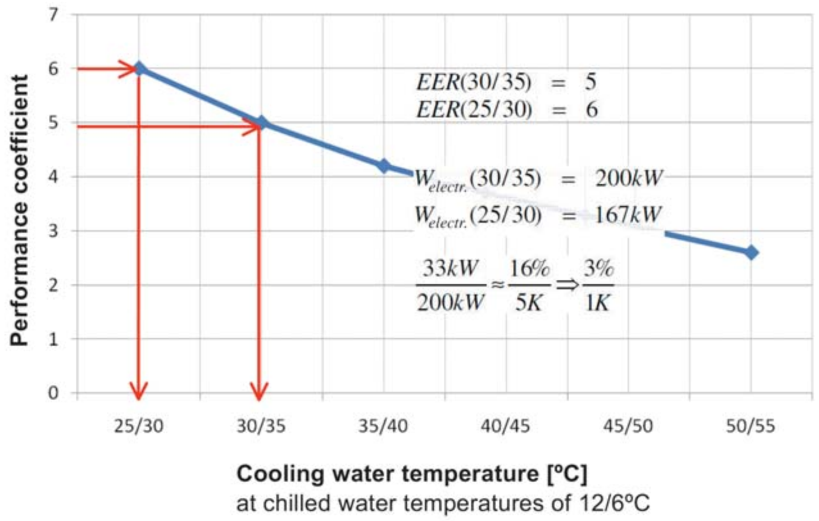
Due to their higher energy efficiency, water-cooled water chillers are increasingly used. The lower the air temperature in the server room (and thus the required cold water temperature), the higher the technical complexity and the power consumption.

For this reason, it is advisable to check which temperature is actually necessary.

It is often thought that the supply air for a server room must be cooled below 20°C; according to a current recommendation of ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers), however, an air temperature of about 27°C – corresponding to a cold water temperature of about 24°C – provides the best results.



The diagram below shows the EER of a modern turbo-compressor chiller



Green IT – climate change has reached data centers

Energy efficiency of cooling plants and possible savings. Modern water-cooled water chillers have an EER (Energy Efficiency Ratio) between 4 and 6 during full load operation. Thus, a cooling capacity of 1000 kW requires an electrical energy input of 167 to 250 kW by the compressor.

The electricity costs for the circulation pumps and recoolers add to this amount.

In order to optimize the plant, one must always consider the entire system. There are three starting points for increasing the cooling plant's energy efficiency:

1. Lowest possible condensing temperature, i. e. cooling water from recooler as cold as possible.

2. Evaporation temperature as high as possible, i. e. cold water for load as warm as possible.

3. Exploit free cooling: if the ambient temperatures are low, the recooler takes over the cold water generation, and the energy-intensive refrigeration chiller remains deactivated.

Cooling water temperatures of 35/30°C result in an EER of 5, i. e. a refrigeration capacity of 1000 kW results in a motor performance of 200 kW.

Cooling water temperatures decreased by 5K, i. e. of 30/25°C, result in an EER of 6, i. e. a refrigeration capacity of 1000 kW results in a motor performance of 167 kW.

The reference value one can deduce from this is that a condensing temperature decrease of 1K saves approx. 3% of the refrigeration unit's power consumption.

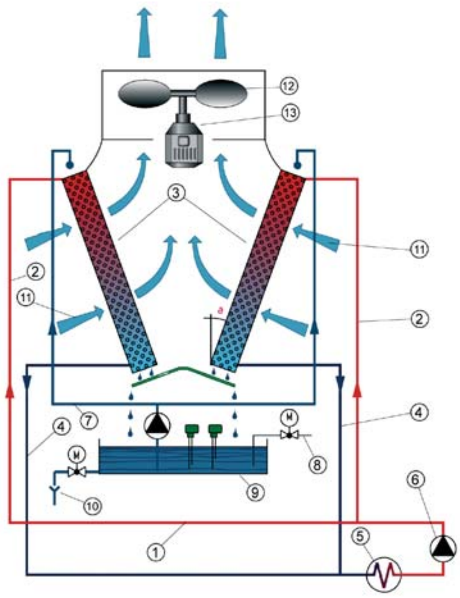
Thus, the additional expenditure for a larger or more efficient recooler will soon pay off.

Functional principle of hybrid dry cooler / Picture: Jäggi/Güntner (Schweiz) AG

Green IT – climate change has reached data centers

Description

1) Primary circuit
2) Fluid inlet
3) Heat exchanger
4) Fluid outlet
5) Heat source
6) Primary circuit circulation pump
7) Wetting water circuit
8) Make up water supply
9) Water basin
10) Blow down water drain
11) Air flow
12) Fan
13) Fan drive



Recooling with hybrid dry coolers.
In many cases, hybrid dry coolers are used as recoolers.

The resulting cooling water temperatures are much lower than those reached by dry coolers and thus make for better EER values for the refrigeration chiller. Furthermore, the hybrid cooler requires considerably less space and power.

As compared to cooling towers, the annual water consumption is reduced by approx. 75 – 90% depending on the design. Further advantages are the guaranteed vapour-free operation, legionella-safe operation and the much lower noise level.

Hybrid dry coolers are optimized for water-saving operation. Thanks to the Jaeggi-HybriMatic® control, the coolers run entirely dry, i. e. with convective heat exchange with the ambient air in the cold season or during partial load operation.

Only when the required cold water temperature cannot be reached any more in dry operation, the wetting circuit is engaged automatically.

Thus, the application of the natural principle of evaporation makes the hybrid coolers extremely energy-efficient. Energy consumption is minimised by using axial fans thanks to axial fans with frequency-controlled speed control and energy efficiency class Eff1 drive motors.

A recooling capacity of 1250 kW and cooling from 32°C down to 27°C at a wet-bulb temperature of 22°C results in the HTK 1.8/10.9 cooler type with a power requirement of 4 fans x 6.3 kW and 2 wetting pumps x 0.9 kW = 27 kW overall.

Hybrid cooler for data center

Green IT – climate change has reached data centers

By now, Jaeggi has produced more than 2000 hybrid dry coolers, among them 185 coolers with an overall cooling power of 230 MW for data centers.

Free cooling with hybrid dry coolers.
The following diagram shows the assembly of the example cooler with a cooling capacity of 250 kW and cooling from 32°C down to 27°C for recooling a refrigeration chiller with 1000 kW.

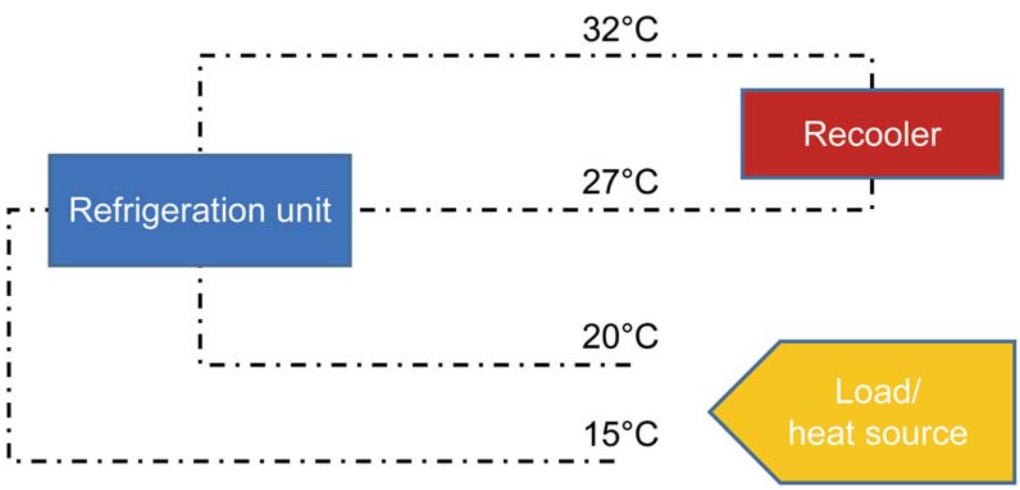


Diagram recooling

Hybrid cooler for air conditioning of computer and server rooms

Green IT – climate change has reached data centers

Free cooling with hybrid dry coolers.
With an appropriate circuit, the recooler can directly take over the cold water cooling from 20°C to 15°C at low ambient temperatures – so-called free cooling, the refrigeration chiller remains inactive. Instead of requiring 250 kW (EER = 4) for the refrigeration chiller plus 27 kW for recooling = 277 kW overall, this method reduces the power consumption to 27 kW, i. e. 90% energy is saved.

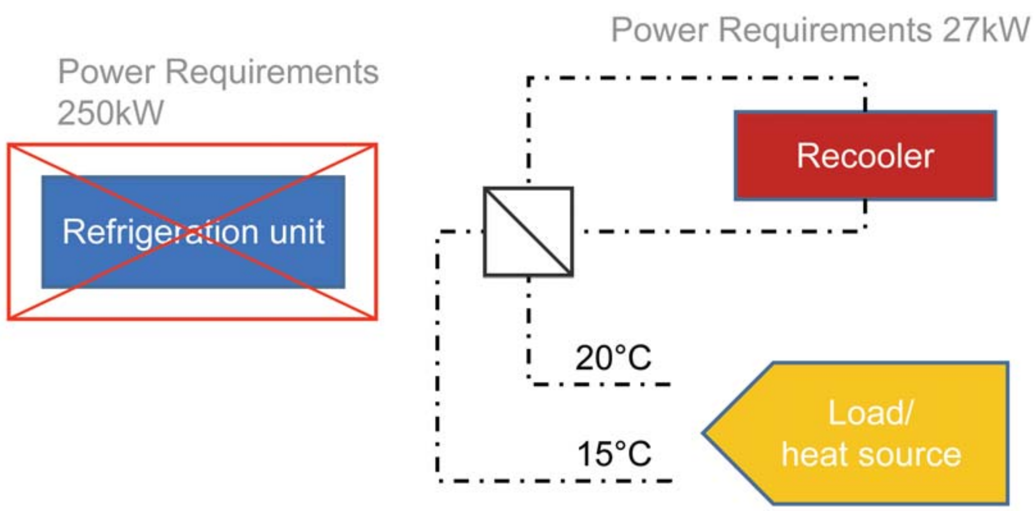
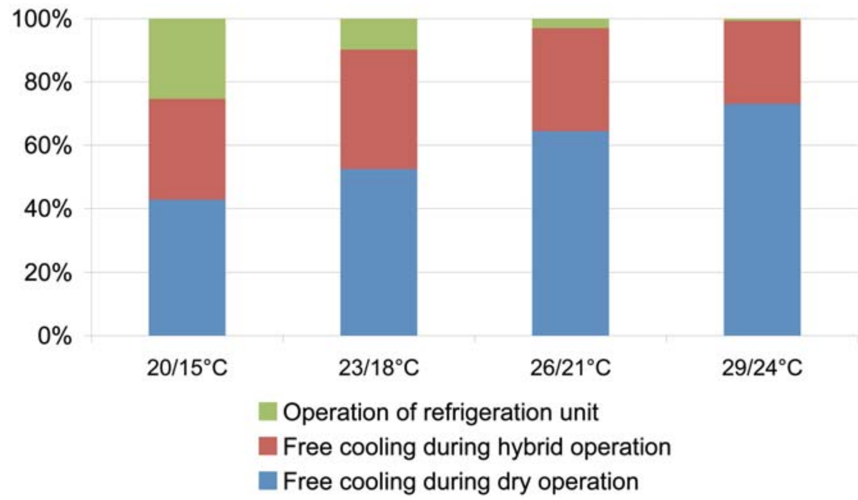


Diagram free cooling

Diagram: Annual operating hours of free cooling with hybrid dry cooler at increasing cooling water temperatures, location: Zürich



Green IT – climate change has reached data centers

Free cooling with hybrid dry coolers.
If, as described above, the air temperatures in the server rooms – and thus the required cold water temperatures – are increased, this results in longer operating periods where energy-saving free cooling can be used while the refrigeration chiller remains deactivated.

Conclusion
In addition to measures such as strictly separating cold and warm air in the server rooms, increasing the room temperature and using hybrid dry coolers for free cooling is an effective method to save energy in data centers.

This method reduces the operating hours of energy-intensive refrigeration chillers and exploits the natural and environmentally harmless principle of evaporation by means of hybrid cooling.

With the air intake temperature of 27°C recommended by ASHRAE, one could do without energy-intensive refrigeration chillers almost throughout the entire year in all of Central Europe.

As long as the refrigeration chiller is running, hybrid dry coolers can provide very low cooling water temperatures, which improves the refrigeration chiller's EER and thus considerably reduces its power consumption.

Author: Joachim Weber,
Jäggi/Güntner (Schweiz) AG

Jaeggi – the original

Jäggi/Güntner (Schweiz) AG
Hirschgässlein 11
CH-4051 Basel

Phone +41 (0)61 560 91 00
Fax +41 (0)61 560 91 01
info@jaeggi-hybrid.ch
www.jaeggi-hybridkuehler.ch