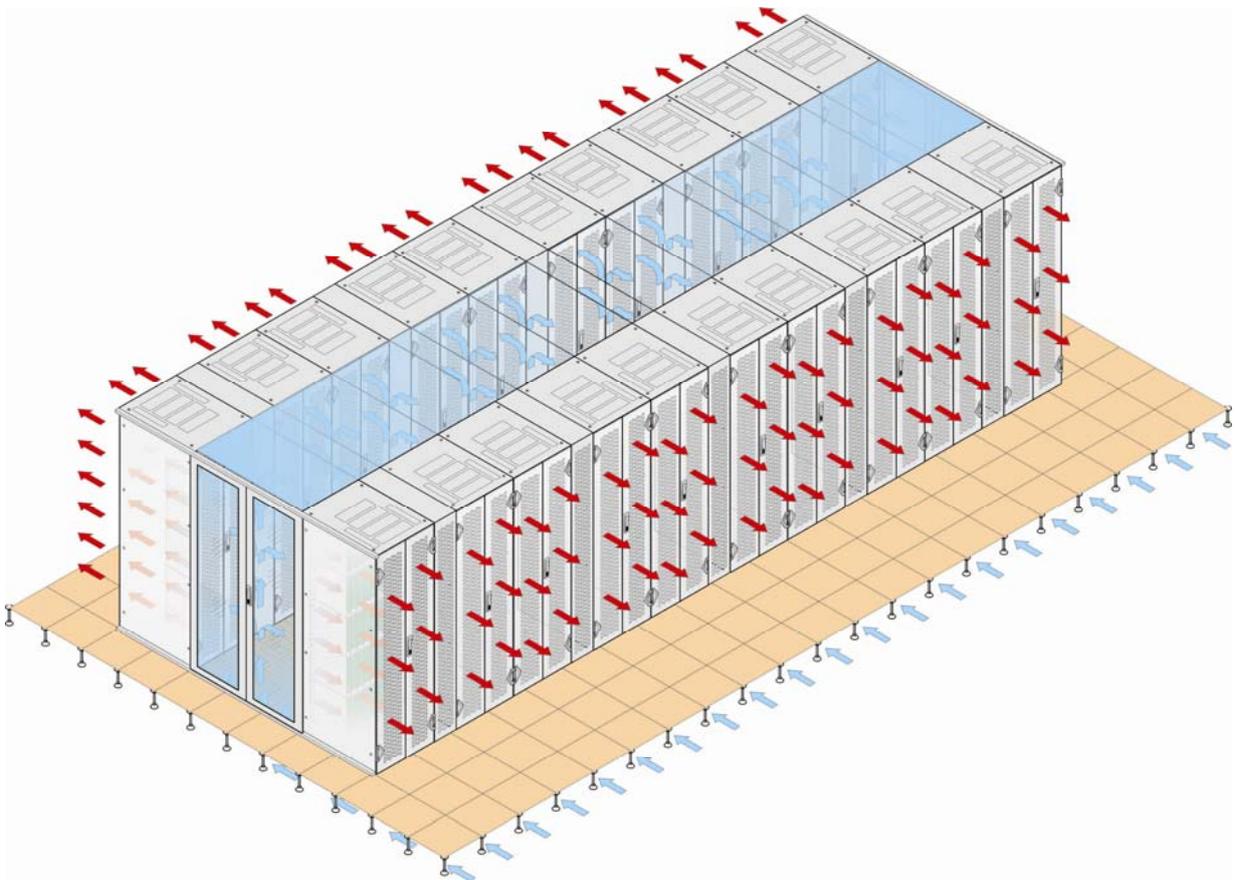


Cold Aisle Containment

THE OPTIMISATION OF HEAT DISSIPATION FROM SERVER CABINETS

INCREASING THE EFFICIENCY OF, OR REDUCING THE LOADING ON,

THE AIR-CONDITIONING SYSTEM IN THE COMPUTER CENTRE



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1. Introduction: Minimising losses, optimising cooling

In recent years the power of servers in computer centres has increased dramatically, and the requirement for cooling has thus also risen. Today, computer centres are still cooled almost exclusively with air. Servers and other IT components are normally housed in server cabinets in such a way that cold air is sucked in through the front from the environment and warmed air is blown out to the rear. For this the cold air is provided by a central air-conditioning system. The loading on this air-conditioning must however be reduced by optimising the cooling in any of the following circumstances:

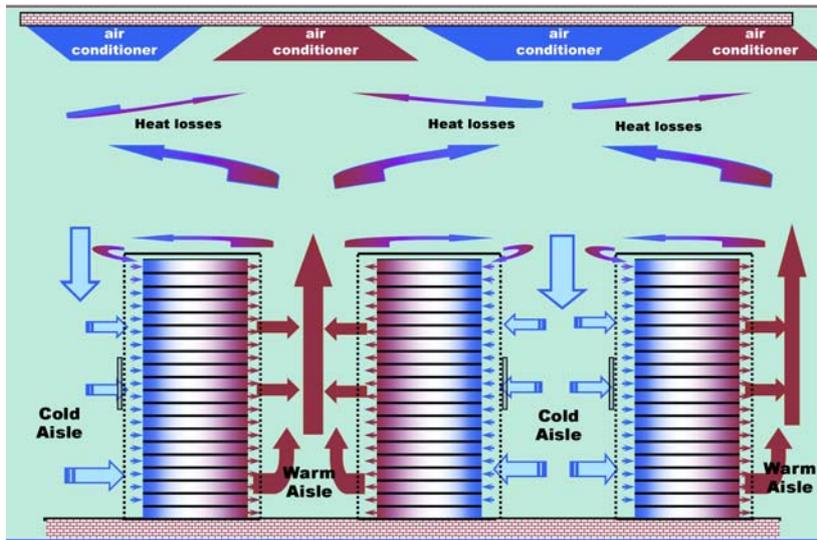
- where additional servers are later added to an existing server room. That is, when the number of installed servers comes to exceed that which the central air-conditioning system is capable of cooling;
- where a non-optimised server-room configuration requires a significant cooling of the space, such that a part of the cooling capacity of the air-conditioning is unnecessarily lost.

2. Server cabinet installations in the computer centre: Cold and warm aisles

For pure air cooling, the maximum possible cooling per server cabinet is determined by the capacity of the surrounding space to supply sufficient cool air to the front of the cabinets and to extract the warm air at the rear of the cabinets from the space. Where server cabinets are arranged in aisles in which the rear of the cabinets of one row faces the fronts of the next row, the cabinets of the second row inevitably draw in directly a proportion of the warm air expelled from the first row. Arranging the cabinets into so-called 'warm' and 'cold' aisles, on the other hand, already optimises the air-conditioning of a computer centre. The suggestions set out below presuppose, however, that the cabinets themselves are already optimally arranged as regards the correct airflow.

2.1 Cold air coming from above

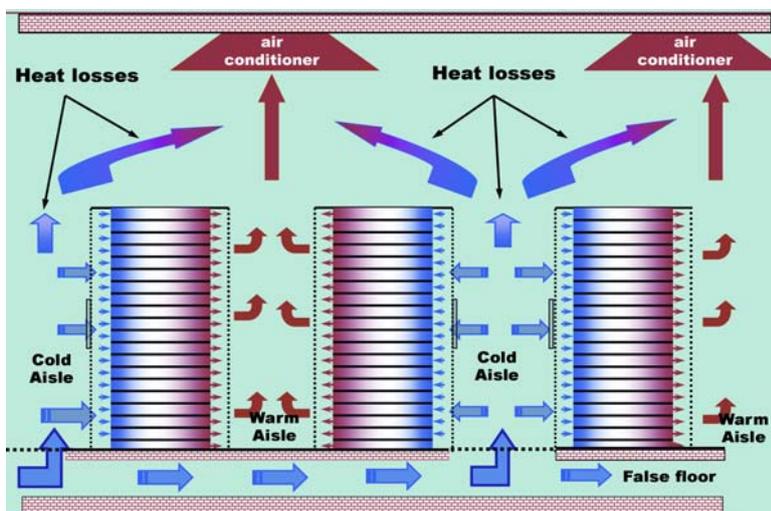
In an arrangement with cold and warm aisles, the cold air can flow into the cold aisles by two different ways. The first: the cold air is supplied by the air-conditioner from above, and the warmed air is likewise sucked upwards or horizontally out of the space (not shown) by the air conditioner.



This is the preferred solution where, for example, no false floor is present. However, it gives rise to relatively large losses. The spatial proximity of the inlet and outlet of the air conditioner is a cause of 'short circuits', whereby a proportion of the cool air is promptly sucked out again with the warm air. What is more, some of the warmed air from the warm aisles is not extracted by the air conditioner but rather becomes mixed with the cool air entering from above, and is then drawn back into the server cabinets.

2.2 Cold air coming from below

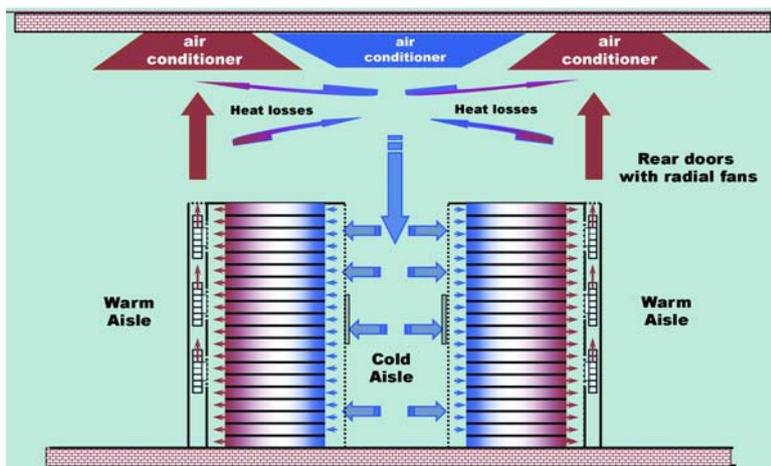
By introducing the cold air from below via a false floor into the cold aisle, some of these losses can be avoided. As with the previous arrangement, the warm air is removed from above by the air conditioner.



The air short-circuits between air inlet and extraction points do not occur here since the inlet (in the floor) and extraction points (ceiling) are sufficiently far apart to prevent them. In providing sufficient cold air to the topmost servers, however, again a proportion of the cold air invariably bypasses the servers altogether and is drawn upward to the extraction point. In such a configuration the cold airflow speed plays an important role. If this is too low, the uppermost servers in the cabinets do not receive sufficient cold air; the air temperature in the upper areas then becomes impermissibly high and hotspots occur. Where the airflow speed is too high, however, the cold air passes the lower servers too quickly and these receive too little cooling. The balancing point is further complicated by the fact that a mixing of warm and cold air occurs in the cold aisle and thus a temperature difference or zoning between the lower and upper cabinet areas. In certain circumstances this difference can be up to 5 K and effectively minimised only by measures for containing the cool air.

3. Optimisation stage 1: Radial fans in the rear doors

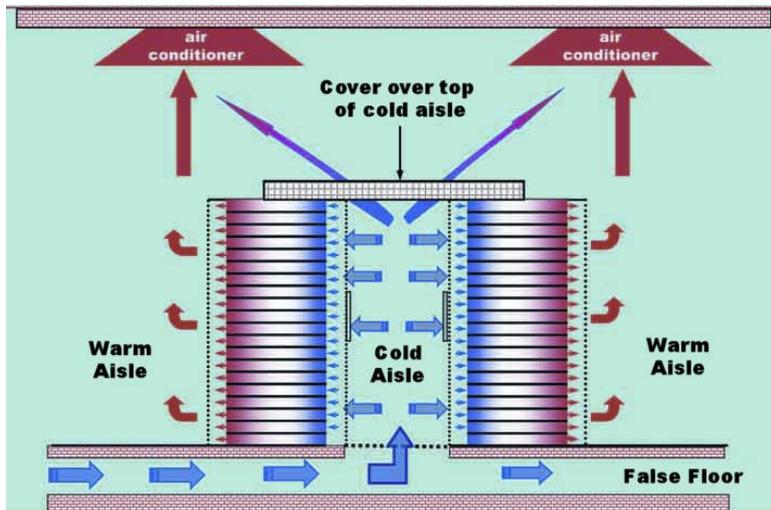
To further improve cooling, the ordinary rear doors of server cabinets may be replaced with doors containing fans. These fans suck the warmed air from the cabinet and blow it directly to the extraction point of the air-conditioner. This approach is used primarily in server areas without a false floor, in order to keep air short circuits to a minimum. Losses are significantly reduced. A further benefit is that the air now flows uniformly throughout the entire height of the cabinet. The latter benefit is also obtained when the solution is used in conjunction with a false floor.



It is quick and simple to swap standard doors for doors with fans, and this can even be done while the servers are operating.

4. Optimisation stage 2: Covering the cold aisle

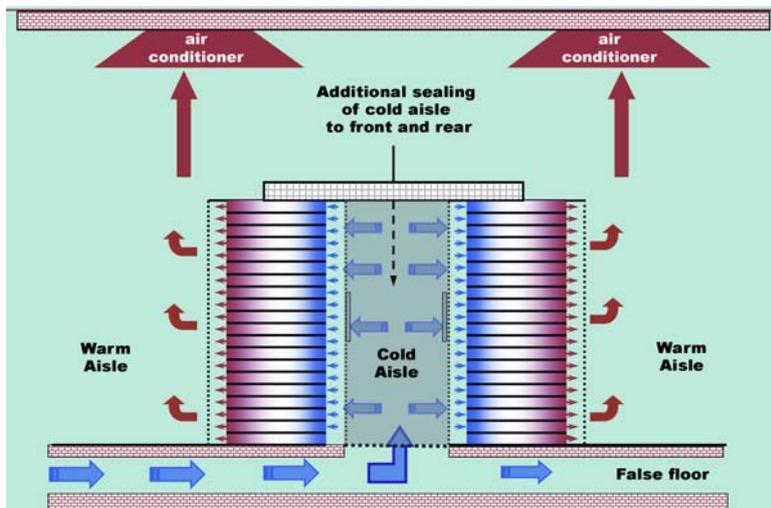
Where the cold air enters from a false floor, various possibilities exist to minimise losses from the cold aisle and to avoid the balancing act between too-high and too-low airflow speeds. The simplest solution is to fit a cover over the top of the cold aisle.



By this means the airflow rate is reduced, for one thing, and for another it is ensured that most of the air fed into the cold aisle is in fact drawn into the server cabinets. The temperature zoning over the height of the cabinet is substantially reduced, which also increases the efficiency of the air conditioner. Nevertheless, losses continue to occur along the axis of the cold aisle (at the front and rear).

5. Optimisation stage 3: Additionally closing the cold aisle front and rear

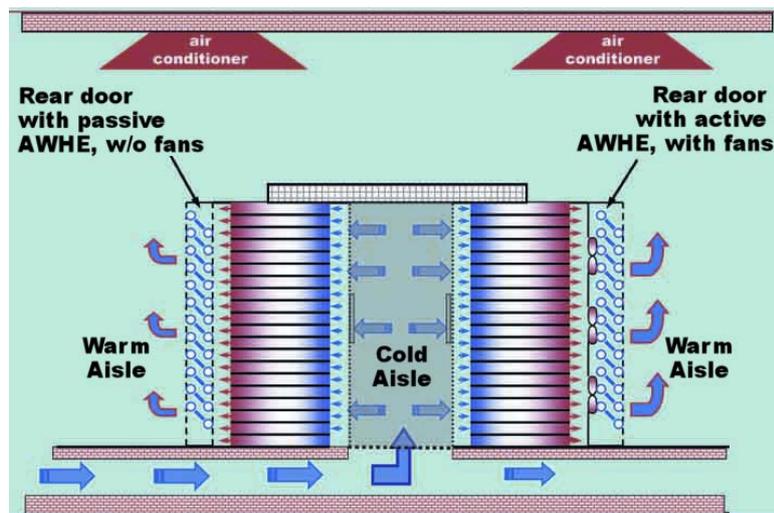
Here, in addition to closing the cold aisle from above, it is sealed to front and rear (by means of a door or hatch).



The result is a cell with a form of forced air circulation: the cold air can only flow through the server cabinets. No losses occur. Temperature differences along the height of the server are effectively avoided by this means, thus optimising the energy demand on the air conditioner.

6. Optimisation stage 4: Water-cooled doors on the exit side of the servers

The next improvement is made by replacing the doors on the exit side of the servers with doors containing either passive or active air-water heat exchangers (AWHE).



The use of active or passive AWHEs in this position considerably reduces the load on the available air-conditioning system. In both cases, the warm air from the servers can be cooled prior to leaving the cabinet to a temperature lower than that of the cool air entering it. This characteristic can be useful in situations where the air-conditioning system has already reached the limit of its capacity, yet additional servers are to be installed.

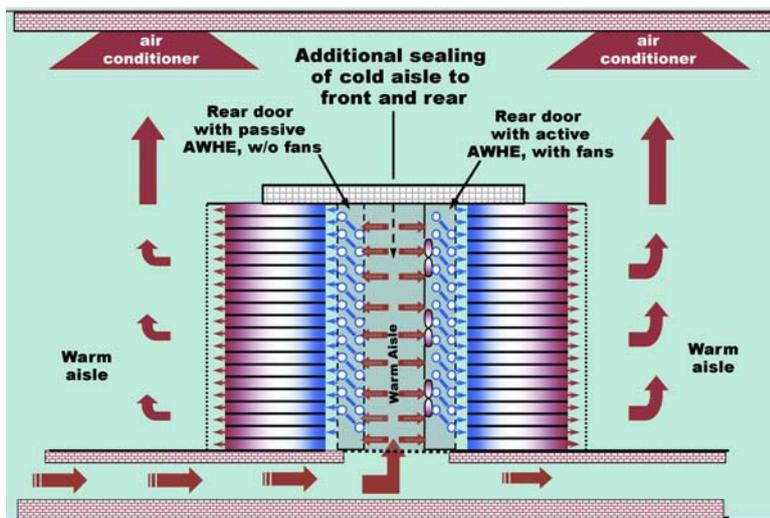
With doors fitted with active AWHEs a uniform distribution of air is obtained throughout the height of the cabinet. The fans of the active AWHEs suck the warm air from the rear section of the cabinet through the AWHE and blow it cooled into the server room. This provides a powerful support for the server's own fans. Where the doors are fitted with passive AWHEs, the air resistance of the heat exchanger must be exactly matched to the server fans to ensure that these are still capable of extracting the warm air.

7. Optimisation stage 5: Water-cooled doors on the entry side of the servers

In this step, the doors on the entry side of the servers are replaced with doors containing either passive or active air-water heat exchangers (AWHE). Such an improvement can only be undertaken, however, if the design of the server units permits it. This is because, in order to be able to operate or monitor the servers from the front, they must be fed with cold air from the rear. In addition the patch cable and other important connections must be routed to the front in order

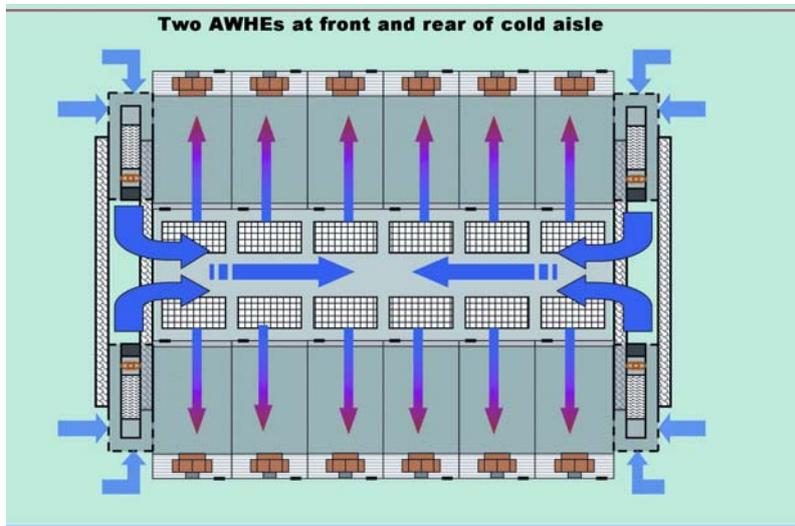
to avoid the need for hinges to the AWHE doors. The user is rewarded for these steps with further attractive benefits:

- No longer is a room air conditioner required. Only the chiller is required, for providing cold water for the AWHEs.
- By employing two-way valves in front of each AWHE, these only use as much water as is necessary to maintain the server temperature set by the user.
- The use of these two-way valves before each AWHE also allows the circulator pump to run very economically, maintaining a constant pressure with variable water volume.
- The not insignificant energy losses from cooling the server room and the false floor - building cooling - are dispensed with. On the contrary, since the room temperature will be significantly higher than that outside the building, a fraction of the heat is given to the outside environment through the wall of the building, thus also taking the load off the water cooler.
- An appreciable saving in energy costs is obtained, which can be further increased by the use of exclusively passive AWHEs.



8. Optimisation stage 6: Closed cell with two AWHEs (LHX 20), at front and rear

Still more effective cooling is obtained by the use of two AWHEs, one to the left and one to the right, within the closed 'cold' cell at the end of the cabinet rows. The rear doors can further also be fitted with radial fans. In this arrangement, separate considerations must be made for installations with and without a false floor. In both cases, however, the efficiency of the server cooling will be greatly increased.



If a false floor is present, the admixing of additional cold air in this configuration gives many immediate advantages:

- The air temperature in the cold cell can be significantly lowered relative to that of the air entering from the false floor.
- The volume of air now delivered to the servers is increased.
- The surplus volume of cold air from the false floor can be made available for cooling other server cabinets.
- The server cabinets close to the AWHEs draw a greater proportion of their cold air from the AWHEs and less from the floor. This allows the centrally-positioned cabinets to draw more cold air from the floor.
- Distribution of the air circuit throughout the height of the server cabinets is much more uniform.

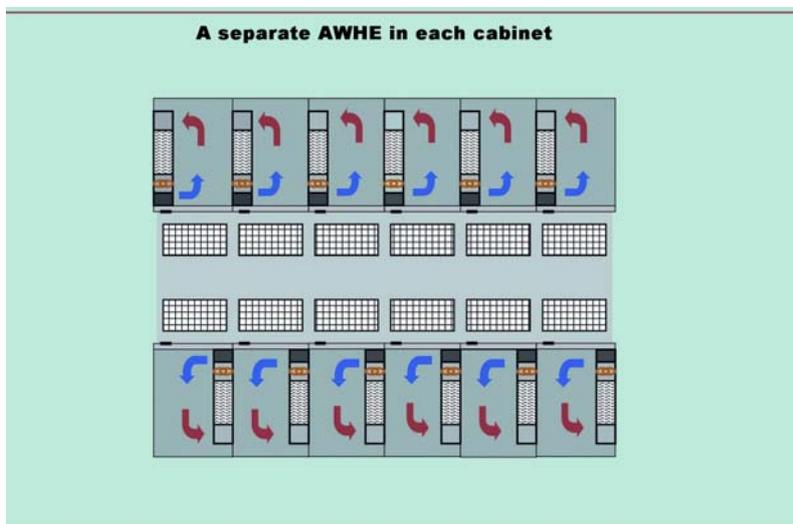
Where no false floor is provided, the maximum cooling capacity of the AWHEs and the availability/supply of cold air to the individual server cabinets must be taken into account. Here also, a number of benefits are obtained:

- The server cabinets can be supplied with significantly colder air than could be provided by the air-conditioning system.
- The load on the air-conditioner can be substantially reduced.
- This design can be applied in rooms that otherwise would not be suitable as server spaces.
- Distribution of the air flow over the entire height of the server cabinets is considerably more uniform, helping to prevent the formation of hot spots.
- The temperature difference across the height of the cabinet is as good as eliminated. The result is higher energy efficiency for the system overall.

It is possible, by using the cooling doors described above with all the advantages stated for them, to extend the effectiveness of the cooling still further.

9. Optimisation stage 7: Air-conditioning for safety only

In this final stage of improvement, all subsequently-installed server cabinets are grouped into closed units and cooled using AWHEs (LHX20). The result is a space-independent cooling design, and the advantages offered by water cooling can be exploited without limit. The inner temperature of the cabinet is matched exactly to the server requirements; the remaining infrastructure is not affected.



This design allows existing computer centres whose air conditioning system is already so heavily loaded that the volume of cold air can be increased no further, but that have reserves for additional water cooling, to expand their server capacity. Existing server cabinets continue to be cooled via the central air conditioning. Where necessary an additional chiller must be provided for the AWHEs.

Where a server room is not being retrofitted but rather designed from new, it will be possible to provide all of the cabinets with space-independent AWHE cooling (LHX 20) from the outset. Only those areas of the computer centre that require cooling will then be cooled; in normal operating conditions the power of the air conditioning can be reduced to a minimum level. The air conditioning system is required only to remove that fraction of the heat that is passed from the surfaces of the cabinets into the space, and also to provide a safety function. In the event that one of the AWHEs should fail, then the door, for example, of the affected cabinet would open automatically and the servers be supplied cold air from the air conditioner for a limited time.

10. Conclusion

There are a variety of possibilities for making improvements to the heat dissipation in existing computer centres. These allow a reduction in the loading of an air conditioning system that is reaching its output limits while also allowing additional server cabinets to be installed. There is likewise potential for further optimisation on the IT side as the energy efficiency of individual devices (e.g. servers) is further improved. Many renowned manufacturers have thus joined open, non-profit-making organisations such as Green Grid and the Climate Savers Initiative.

11. Schroff company portrait and notes on the author

Schroff, based in Straubenhardt, Germany, is a leading developer and manufacturer of electronics packaging systems for electronics, automation, information and communications technologies worldwide. The company's standard products range from cabinets for indoor and outdoor use, cases and subracks through power supply units and backplanes to microcomputer assembly systems including air conditioning. With this product platform as its basis, Schroff is able to realise customer-specific modifications quickly and at advantageous cost. Schroff's comprehensive integration service draws together its product and service competences to create a total solution with real customer benefit. Our products and services are the result of decades of focussing on the global interests of the electronics markets. Schroff has consistently built on its core competences such that today its expert knowledge in electronics packaging, thermal management and electromagnetic compatibility brings additional added-value to these fields.

Adam Pawlowski, Dr-Ing., is a graduate of the aircraft engines department of the Politechnika Warszawska in Warsaw, specialising in combustion processes. During his time employed as an academic at Berlin's Technical University he completed his doctorate in the field of mechanical vibration principles. In the course of his professional development he worked for many years as a division head in the area of R&D climate-control technology for companies engaged in climate-control equipment for switchgear and in the automotive industry. Since August 2005 Dr Pawlowski has acted as product manager for climate-control equipment at Schroff GmbH.