

## Free air cooling in data centres

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The vast majority of computer rooms are cooled by air conditioning systems that attempt to deliver cold air to hot IT equipment placed in racks.

A few systems use cold water pumped around the rack and there are even some exotic solutions using liquid carbon dioxide and even chip level cooling. The majority however use cold air derived from direct expansion or chilled water-fed air-conditioning units.

The air-conditioning units themselves vary from 'office-grade' comfort air-conditioning units to precision controlled units specifically designed for 24/7 operation in a computer room environment.

The amount of cooling capacity delivered to an equipment rack depends upon the design of the system and how effectively it has been implemented. Although the press is full of claims and adverts about eight or even twelve kilowatts of air cooling achieved in a rack the reality is more likely to be in the order of four to five kilowatts in a realistic and cost effective model. Even four kilowatts depends upon a well-engineered air delivery path and optimised rack layout. Four kilowatts equates to about 16 1U rack mounted servers.

The amount of energy consumed by air conditioning systems within data centres is becoming a cause for concern.

Research has shown that the average data centre expends 35% of its total energy consumption on cooling. According to the EU in 2006 the energy consumption by data centres in Europe was 46 TW.hrs, which must mean that 16 TW.hrs, or 16 million megawatt hours has been consumed by computer room/data centre cooling systems. Put another way this is equivalent to 6.75 million tonnes of carbon dioxide per year, and by 2020 total data centre electricity consumption is predicted to rise to 93 TW.hrs. If we take electricity prices at just 0.1 Euro per kilowatt.hour (and rising rapidly), then 1.6 billion Euros is being spent on electricity for cooling every year.

The average computer room/data centre is spending 61,000 Euros per year on electricity for cooling. It is not surprising therefore that everybody is looking at ways of reducing cooling costs.

There are many simple things that can be done to improve the efficiency of cooling in computer rooms. It is already estimated that 50% of all cold air produced by data centre air conditioning equipment is wasted, i.e. it does not pass through the hot information technology equipment. There are some simple ways to improve on this.

Some of the simple steps are;

1. Put blanking plates in server racks to force cold air to pass through the equipment and also to prevent hot air from being pulled back to the air intakes
2. Put the server racks in long parallel rows in the hot aisle/cold aisle format
3. Ensure the raised floor is properly sealed at the edges and has no missing tiles so that cold air is delivered to the cold aisle without waste
4. Use brush grommets where cables enter from the floor into the bottom of a rack. This prevents cold air from entering the bottom of the rack with the cables and interfering with the front-to-rear cooling regime

5. In a similar manner patch panel that are placed at the front of a rack should only allow patchcords to transit to the back of the rack via brush panel so that once again cold air isn't following the cables
6. Increase the average temperature. Many design documents, such as the TIA 942 standard, call for tight control over temperature and humidity in computer rooms. In reality the IT equipment is not that sensitive. Current input temperatures are currently targeted at 18-20<sup>0</sup> C but this could be allowed to rise up to 22 or even 24<sup>0</sup> C. This might make the computer room a bit uncomfortably warm for any human occupants but it will expend less energy on the cooling plant
7. Widen the humidity tolerance on the air conditioning plant. Current standards, e.g. TIA 942 call for tight humidity tolerance bands around 50±5% RH. This is unnecessarily tight and requires a lot of energy to maintain. Most IT equipment will be happy in an environment of between 35 to 75% RH. Very low humidity, i.e. below 30% must be avoided as this is a major cause of electrostatic discharge within electronic equipment and subsequent failure. ASHRAE widened the recommended temperature and humidity settings for computer rooms at the end of 2008.

Some of the longer term steps include;

1. Enclosed cold aisle systems. This method puts a roof over the top of the cold aisle and doors at the end of the two parallel rows of racks. This constrains the cold air into the cold aisles and so it really has nowhere to go but through the hot IT equipment
2. Install a dry cooler into the air conditioning plant. This is a device which bypasses the traditional compressor route (the largest consumer of electricity in air conditioning systems) and allows the refrigerant to condense directly without the compression phase. It can be very beneficial in colder climates.
3. Use external air to supplement the air conditioning system. This is sometimes called an airside economiser. This can be very beneficial in cooler climates.

### **Air side economiser**

In the temperate latitudes that the UK and the Netherlands find themselves there is much scope available for using the relatively low external air temperatures available to us for most of the year. Many data centre still adopt the closed model whereby hot air is returned to the computer room air conditioning units, CRACs, cooled and then sent back around the circuit again, virtually regardless of external temperatures.

The average temperature in the Netherlands, in July and August is 17 to 18<sup>0</sup> C. Some scope is therefore available for free cooling even in the summer months. Averages can be misleading however. In July 2006, in the Netherlands, the maximum temperature was 36<sup>0</sup> C with the whole month exhibiting daytime temperatures of between 24 and 36<sup>0</sup> C and night time temperatures dropping to only 20<sup>0</sup> C. It is essential that data centre cooling systems are designed to cope with the worst case, i.e. 36<sup>0</sup> C, plus solar gain of the building, even if there are savings to be made for the rest of the year.

The basic air side economiser will take in external air when it falls below 20 – 22<sup>0</sup> C and use it to supplement the traditional air conditioning. The hot air produced by the IT equipment is simply dumped outside rather than expending energy cooling it. Even better the hot air is put to good use by supplementing the heating for the rest of the building or some other purpose.

Above 22<sup>0</sup> C there is no point in importing hot air from the outside. At this stage the data centre air conditioning would work in its normal manner.

If the external air was always between 10 and 20<sup>0</sup> C and the air was clean with humidity levels of around 60% then the mechanics of an air economiser system would be very simple indeed.

Unfortunately this is not the case and other situations need to be taken into account.

**Humidity.** Humidity must be kept between 35 and 75%. Fortunately in the area of the UK and Holland extremes of humidity are uncommon, which is not the case in other parts of the world of course. The computer room CRAC units still need to have some level of humidity control although not every CRAC unit needs full humidity control.

**Smoke and dust.** It is important not to import smoke and dust into the computer room, especially smoke as this will set off the sensitive gas fire suppression systems used in modern data centres. Incoming air needs to be filtered and monitored for smoke and the inputs turned off if smoke is detected.

**Low temperatures.** Although we are looking for chilled air the It equipment is not particularly happy below 10<sup>0</sup> C and definitely does not want subzero air. This could lead to all sorts of freezing and condensation problems. The system therefore needs to monitor external air temperatures and either turn the air intakes off at low temperatures or mix some of the return hot air with the very cold external air to get back to the target temperatures of 18 to 20<sup>0</sup> C.

**Fire systems.** The mechanical damper systems must be connected to the fire detection and suppression system. In the event of a fire alarm the dampers must be closed so that the fire suppression gas can do its work without escaping from the room. When the fire is over the dampers must be able to be manually opened so that the gas can be purged from the room.

## Conclusions

Free air cooling can reduce electricity consumption by air conditioning systems by 40 to 60% per year in the temperate latitudes of the UK and the Netherlands.

The simplest method is to duct the external air to the tops of the conventional CRAC units so that the CRAC units supply the fans to move the air into the room plus provide filtering, temperature and humidity control and monitoring.

A proper control system needs to be in overall charge to detect external temperatures, external smoke, the status of the building fire alarm and suppression system and control all the extract fans and dampers accordingly.

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