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Good advice for saving electricity in the server room

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Server room power consumption represents a large proportion of the total consumption of electricity in office buildings. Thus, significant savings can be achieved by focusing on the server room – with consumption often decreasing by 30–50 per cent. The following pages offer some advice for saving electricity in the server room.

Saving electricity is a high priority in offices and other work places – for example, through the purchase of flat screens and notebook computers, and by focusing on lighting. But not much thought goes into power consumption in the server room, where the emphasis is on security and uptime.

In fact power used in the server room represents a large proportion of the total consumption of electricity in office buildings – about 200 GWh per year, a third of which is used for cooling (air conditioning) the server room.

Thus, significant savings can be achieved and, as demonstrated by a pilot project run by the Danish Electricity Saving Trust, server room power consumption can actually be halved (see www.serverrum.sparel.dk).

Substantial savings can be made by choosing power-efficient IT equipment. In addition, the need for cooling can be reduced if power consumption, and thus heat load, is reduced. Simultaneously, the server room should be efficiently located and laid out, and free cooling and a good cooling system installed.

The following pages offer practical advice for saving electricity in the server room under various headings:

- Location of the server room
- Servers, disk drives and power supplies
- Other power-consuming equipment in the server room
- Cooling
- Examples of savings that can be achieved with existing cooling systems
- Purchasing policy and advice

Location of the server room

To minimise the need for cooling, the server room should be located in an unheated part of the building that offers the best possible thermal loss. Therefore the following should be noted:

- The server room should not have east, south, or west-facing windows to prevent ingress of the sun's warmth. Windows facing these directions must be fitted with heavy-duty blinds
- The server room should not be adjacent to a room with a high temperature – a boiler room for example
- The server room should have high thermal loss surfaces – for example, a large uninsulated north wall – or be located in a basement room with uninsulated walls and floors
- The server room should not be located in too small a room, because the temperature in a small room rises very quickly if the cooling system fails
- The server room should not be used as a storage area.

Servers, disk drives and power supplies

It is important to utilise the most energy-efficient IT equipment available. Devices not in use can also be switched off – for example, application servers not required outside normal working hours, and back-up units.

Uninterruptible power supplies (UPS) that ensure orderly shutdown in the event of a power failure consume very high levels of power. UPS efficiency should be greater than 90 per cent in relation to the actual output required.

Power supplies to servers, disk drives and the like are often not particularly efficient – frequently 50 per cent or less in the normal working environment. This means that half the energy consumed is wasted, and in addition this has to be 'cooled' away, which increases the electricity required to power the cooling system. It is difficult to establish the efficiency of power supplies but when commissioning new equipment users should definitely stipulate that these be at least 80 per cent efficient, or preferably over 90 per cent in a normal working environment for IT equipment.

When undertaking consolidation of servers – i.e. when combining many virtual servers onto fewer servers (Fig. A) – the number of servers can be reduced, which thereby also decreases the power consumption required to run the applications. The number of disk drives can also be reduced by aggregating the disk capacity in a so-called Storage Area Network (SAN) solution, where servers share the total disk capacity (Fig. B). In most cases this will lead to a reduction in power consumption to servers and disks of between 20 and 35 per cent.

Example of server consolidation

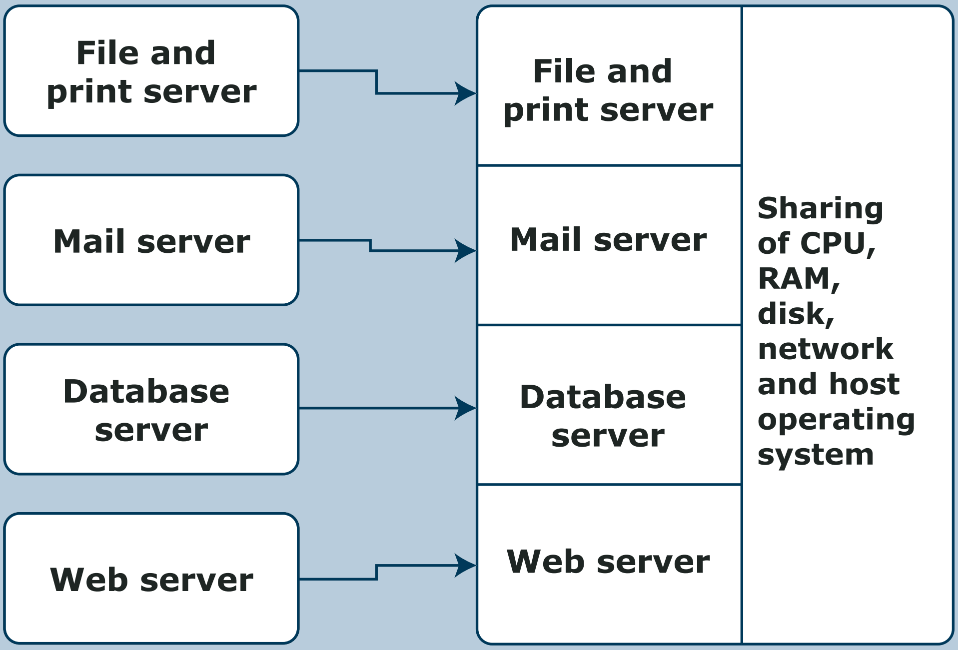

Fig. A Data from four servers consolidated onto one server, and four previous servers switched off.

Example of SAN

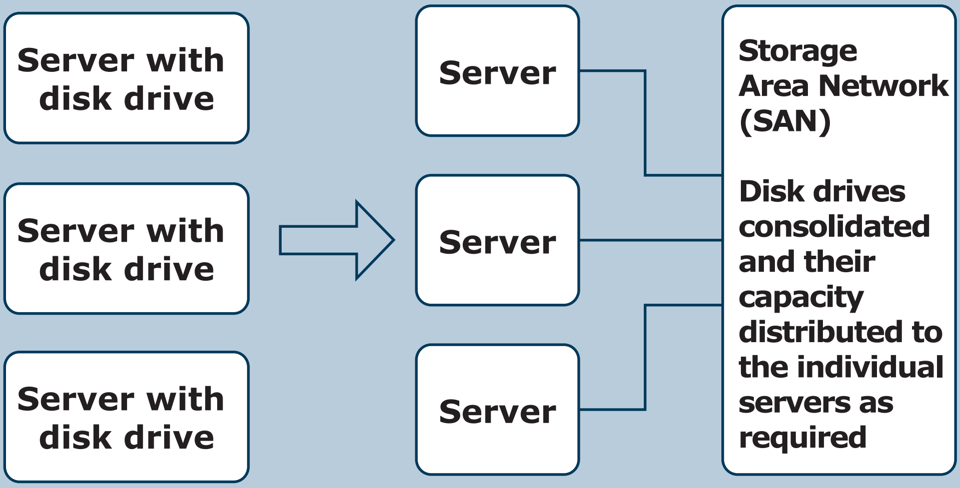

Fig. B Disk drive capacity consolidated into one SAN to which servers have access.

Other power-consuming equipment in the server room

Electricity savings can easily be achieved by applying common sense, for example:

- Move equipment that does not require cooling out of the server room
- Remove all unnecessary equipment from the server room – for example, phones and UPS units, plotters and printers. Similarly, the main distribution frame including equipment that does not require cooling should be located outside the server room
- Switch off all external devices that are not in use – for example, tape units that are only utilised for a few hours at night
- Switch off all lights when no one is in the room. Use low energy light bulbs or fluorescent tubes
- Switch off all unused screens. A screen running a screen saver or on standby uses a significant amount of power
- Keep the door to the server room closed if the temperature in the sever room is lower than the surrounding rooms.

The purpose of a server room cooling system is to maintain a low temperature to vital elements of the installed IT equipment (CPUs, disk drives, UPS batteries, etc.), which will otherwise shut down with collateral damage to associated equipment. These vital components are not normally cooled directly. Instead, the cooling system directs a stream of cold air to the installation's vital components via the built-in cooling fans in the servers, hard disks, etc.

To achieve energy-efficient cooling of the server room it is thus important that the cold air from the cooling system is ducted as directly as possible to the components that require cooling. Furthermore, mixing cold air from the cooling system with the warm air produced by the IT equipment should be avoided.

Additionally, it is important to investigate the possibility of utilising external cold air to cool the servers – using a ventilator for example. If a cooling system is required, a high-efficiency unit should be chosen. Also make sure that the ventilator or cooling system can run when it is needed – i.e. activated thermostatically.

Layout

The server room can be laid out in different ways, although these are often not good in air-conditioning technology terms. To achieve energy-efficient cooling of the server room it is important that the cold air from the cooling system is not mixed with the warm air from the IT equipment.

In the following section the term 'total cooling efficiency' or just 'cooling efficiency' is used. This represents the efficiency of the cooling system less the efficiency lost in the process of conveying the cold air to the IT equipment. This equates to the total heat generated by the IT equipment (total power consumption) divided by the power consumption of the cooling system.

The following section describes several good server room layouts.

Server room with cooling coming up through the floor (EDP flooring)

Typically used in larger server rooms: this type of server room has potentially the best air flow in that the most minimal mixing of cold and hot air occurs if the server room is laid out as shown (Fig. 1), where the cold is vented through ducts between the racks (cupboards with perforated covers and side rails onto which the equipment is screwed). Even better cooling can be achieved if the cold air ducts can be screened from the rest of the room.

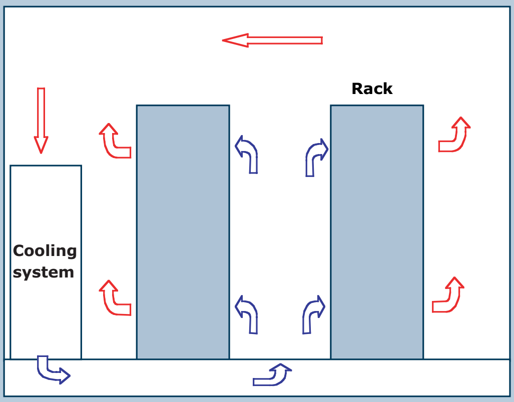

***Fig. 1** Server room with cooling up through the floor. The air is vented between the servers in the racks with perforated covers.*

It is important to ensure that the cold air does not flow freely through the rack – for example, if this is not completely full. Any gaps in the rack should be blocked off with baffles so the cold air is not wasted, and circulates through the IT equipment and is thereby only used for cooling.

This type of layout allows the temperature of the cold air delivered to the IT equipment to be high – in principle up to 30°C, which increases the total cooling efficiency (although in practice the temperature ought to be slightly lower at 25–26°C so as not to run the equipment at its limits).

If the cold and warm airflows mix, or if the air is not circulated consistently to all the equipment, then the temperature of the cold air from the cooling system has to be reduced. Power consumption for cooling rises by 1–3 per cent for every degree for which it is necessary to reduce the temperature of the cold air. Frequently, the temperature of the cold air delivered through the bottom of the racks in a server room can be 10–15°C, which means that power consumption is 10–50 per cent too high.

Free cooling

Even lower power consumption can be achieved by using free cooling – either by harnessing the air outside, or via a liquid circuit. Typically, power consumption in this situation can be halved. Figures 2 and 3 illustrate free cooling.

Free cooling using external air

For most of the year the outside air temperature in Denmark is below the required air temperature for IT equipment in server rooms (i.e. under 20°C). Thus, savings can be made by using external free cooling – for example, by blowing external air through the server room (Fig. 2). Cooling can also occur through the floor and in front of the rack (Fig. 1).

However, the cooling system should nonetheless be configured to handle the whole cooling process because in summer the outside air temperature can exceed 25°C, which is too high to use free cooling. It is important to remember that free cooling replaces active cooling during periods when the cooling system is most effective – i.e. when it is cold outside. Therefore it should be noted that power consumption for cooling reduces less than the reduction in the cooling system's operational time would otherwise indicate.

Users of external air free cooling must ensure that the air to the server room is pre-filtered, and that fire dampers are fitted on the intake and exhaust for increased fire protection. For example, this can be achieved by using an inert gas device that releases N_2, Ar or CO_2 to extinguish the flames.

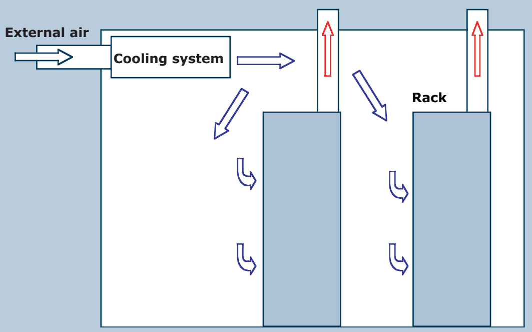

Fig. 2 *Example of free cooling with external air.*

As small a ventilator as possible must be used for the inlet and exhaust to reduce power consumption.

Warm air extracted has a temperature of 30–35°C and can therefore be advantageously recycled to the building's heating system where it can be used to preheat the fresh air into other rooms. This saves additional energy.

Free cooling with a liquid circuit

Free cooling via a liquid circuit can be connected as shown (Fig. 3). In this situation a condenser is located together with an evaporator and compressor. The compressor is cooled via a liquid circuit with an eternally located heat exchanger. In addition, an extra heat exchanger is connected to an evaporator, which is also connected to the liquid circuit. The unit can operate as a traditional cooling system (Fig. 3, solution A), but can also operate purely with free cooling under low air temperature conditions (Fig. 3, solution C). Combined cooling with both free cooling and compressor cooling is also possible (Fig. 3, solution B).

Examples of poor server room layouts

The following section offers examples of server room layouts that typically result in excessive power consumption.

Air conditioning

Smaller server rooms are often cooled by small split systems (Fig. 4). With this cooling method, the unit operates as an air conditioner that attempts to maintain a constant temperature in the room. This is a poor layout in cooling terms because warm and cold air are mixed in the room. Also, it is difficult to achieve a constant temperature for the different IT components. For this reason the cooling system has to operate at a low temperature setting, which results in increased power consumption.

Cooling up through the floor

Figure 5 shows an IT system cooled in essentially the same way as in Figure 1, except for the fact that the warm air from the first row of racks is circulated over the next row of racks where it is sucked into the IT equipment. Thus a powerful mixing of cold and warm air occurs. This makes it necessary to significantly reduce the temperature of the cold air from the cooling system, which causes power consumption to rise.

Another frequently used alternative involves circulating air through racks (Fig. 6). This cooling method is often very inefficient because the upper servers are cooled significantly less than the lower servers. Frequently, because they are heaviest, UPS units are installed lower down. Thus a large part of the cool air dissipates before

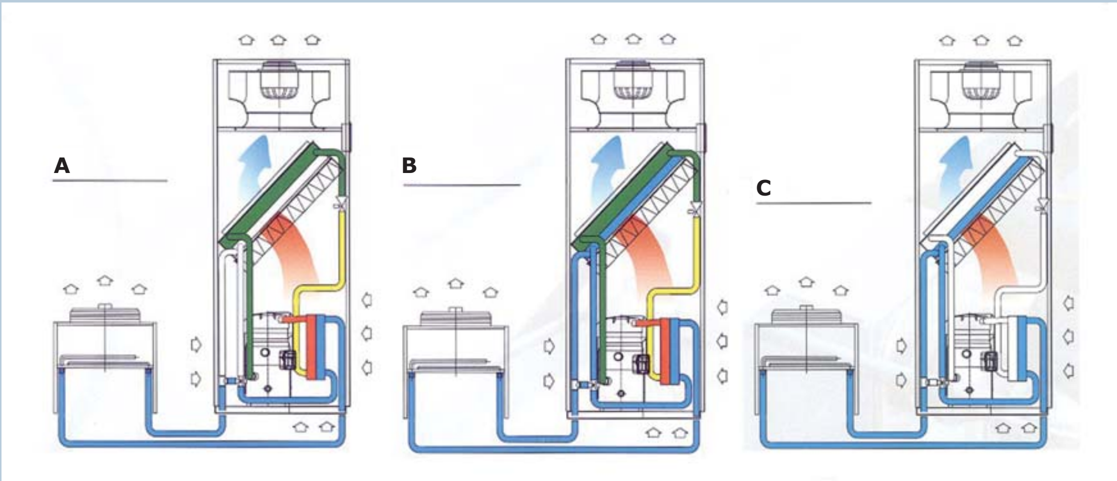

Fig. 3 *Example of free cooling assisted by a liquid circuit in a commercial unit produced by a Danish company, UniCool A/S.*

Servers are either positioned on shelves as shown in Fig. 4A, or in racks as shown in Fig. 4B.

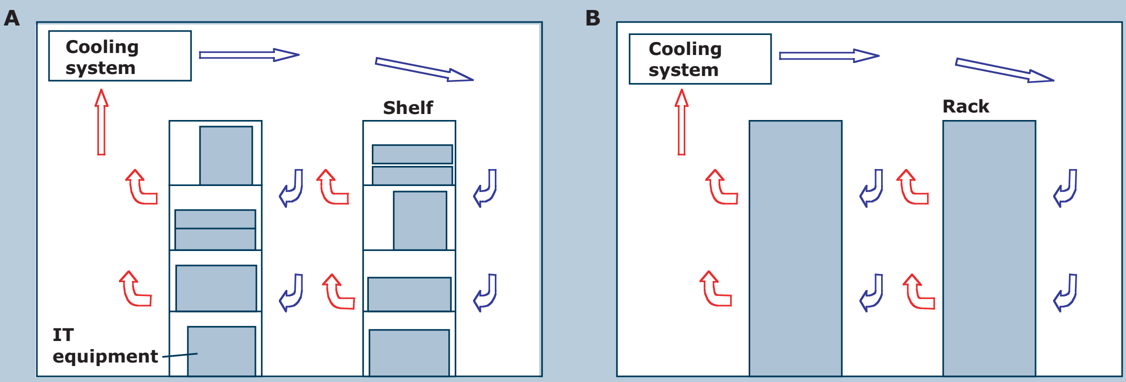

Fig. 4 *Server room with air conditioner style cooling and servers on shelves or in racks.*

it reaches the upper servers (Fig. 6A). Similarly the cold air is heated up by the lower servers before it reaches the upper ones (Fig. 6B). Also, in connection with solution 6B, the servers are often positioned too close to the front cover, which means that the cold air is not easily drawn into the servers higher up the rack.

In this situation the cold air from the cooling system also has to be at a very low temperature, which also leads to high power consumption.

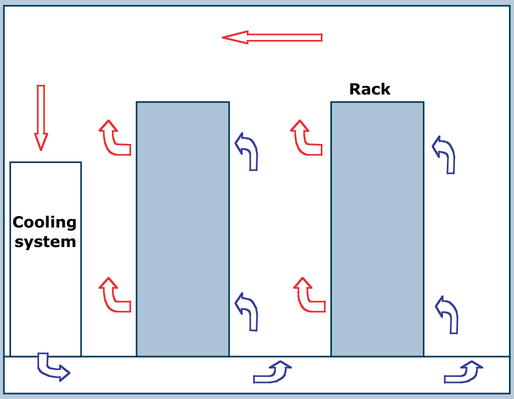

Fig. 5 *Server room with cooling up through the floor in front of servers in racks with perforated covers.*

Mechanical cooling

Cooling accounts for about 30 per cent of the total power consumption in a server room. Therefore it is very important to choose the right system and install it correctly. Service and maintenance naturally also play a part, and in line with current personal safety legislation cooling systems must be serviced at least once a year (cf. The Danish Working Environment Authority regulation No. 932, 17 November 2003).

When choosing a new cooling system the following should be in focus:

- Always investigate the possibility of free cooling
- Try to obtain the best COP (Coefficient of Performance) under standard conditions, which is 27°C intake and 35°C exhaust. For factory produced systems COP must be three or over
- Ensure that the total efficiency of an on-site constructed system is not worse than the equivalent factory-produced unit
- The cooling system ought to be stepless (or multi-adjustable)
- The cooling system's condenser (outer element) must be positioned externally – preferably in a well-ventilated shaded location
- The cooling system must be correctly adjusted and serviced annually.

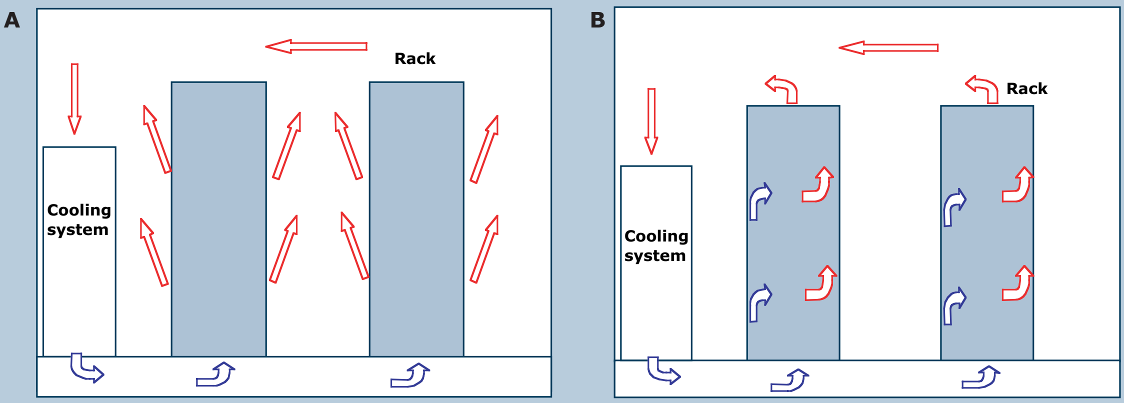

Fig. 6 *Server room with cooling up through the floor and up through the racks. The racks (Fig. 6A) have perforated covers, whereas the racks (Fig. 6B) have solid covers.*

Examples of savings that can be achieved with existing cooling systems

The following section describes what can be done to obtain savings from existing cooling systems, and the benefits achievable.

In general, it is difficult to make major changes to existing cooling systems unless a user is prepared to invest large amounts on expanding the facility, replacing surfaces or even changing the complete system. Therefore, initially it makes sense to try a couple of different measures before taking the decision to embark on a total system replacement. For example, it is possible to:

- Increase the server room temperature, which in terms of power consumption can save 1–3 per cent for every degree increase in the room temperature (max temperature governed by the IT hardware in the room, although too much heat will reduce the life of the equipment)
- Reduce the total heat loading in the server room as described under servers, disk drives and power supplies above, because 0.5 kWh on cooling is saved for every kWh reduction in powering the IT equipment
- Implement free cooling based on external air. Typically, a great deal can be achieved, and in many cases this can produce savings of more than 50 per cent
- Move possible split systems' external components to a favourable position – such as a shaded outdoor location that offers the possibility for significant airflow around the unit
- Prevent 'short circuiting' of the airflow – in many cases the air returned to the cooling system will be mixed with the cooled air from the system. This is very inefficient and can normally be avoided by ensuring that the baffle plate of a split cooling system is properly fitted for example
- Make sure not to cool more than necessary – this often happens and wastes considerable energy
- Make sure that the system has an unobstructed air passage – thereby ensuring that the cold air is ducted directly to the servers.

Cooling should be a high-priority activity, instead of it being generally of secondary importance that simply needs to be there – which is often the case.

Purchasing policy and advice

Operational security in the server room is by far the most important because down time is a major problem for most organisations. But it is possible to save electricity without compromising operational security.

Be aware that power consumption represents a significant proportion of the overheads of a server room. The Danish Electricity Saving Trust's research revealed that the average server room consumed 200 kWh per year, which is equivalent to over DKK 300 per employee per company. However, consumption varied between 50 and 400 kWh. A single server can easily use DKK 2,000 of electricity per year, with additional power required to cool the server.

Purchasing policy for IT equipment and cooling equipment should therefore take power consumption into account. This can be done by checking the power rating of new equipment, by taking electricity costs into consideration in the overall assessment of the operational overheads, and by making demands on manufacturers.

Additionally, a useful starting point is to know the power consumption of your server room. It is a worth installing a meter if one does not already exist.

Calculate total overheads

When putting IT equipment and cooling systems out to tender, make sure that the offers are for energy efficient equipment. In cost comparisons, do not focus simply on the investment cost, but also factor in the TCO (Total Cost of Ownership) to include the electricity costs over the equipment's lifetime.

Most IT equipment is constantly 'on', and the annual power consumption can easily be calculated by multiplying the powered-up use (in kWh) by the total number of annual hours (8,760) by the cost of electricity. Suppliers should be able to provide powered-up consumption figures.

Suppliers or manufacturers of cooling equipment can provide information on the approximate annual power consumption, thereby allowing annual electricity costs to be calculated.

Typically, depending on the type and the organisation's replacement policy, the lifetime of IT equipment is 3–6 years. The lifetime of cooling systems is generally 15 years.

IT equipment

As mentioned, purchasers of IT systems should check the equipment's power consumption. UPS efficiency should also be checked. Additionally, checks should be made to establish whether the equipment has built-in hibernation and automatic power-off functionality, which automatically reduces power consumption when the equipment is not in use for a pre-defined period.

The previously mentioned possibilities for server consolidation (where many virtual servers are consolidated onto one physical server, combined with SAN and hard disk capacity) should also be investigated when embarking on a new layout, or where major changes are made to the server room.

Cooling systems

There are many excellent and energy-efficient systems available, and this is one area where it is easy to choose a cooling system with lower total overheads.

Typically cooling systems are in service for more years than IT equipment and it is therefore important to choose an efficient system. As previously mentioned, the possibilities of free cooling should be investigated because this type of cooling can often reduce power consumption by 50 per cent.

The COP of a cooling system should be researched along with its approximate annual power consumption. Thus, purchasers can choose a system with a high COP and low annual electricity costs.

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The Danish Electricity Saving Trust

The Danish Electricity Saving Trust is an independent trust led by a Board appointed by the Danish Ministry of Transport and Energy. The Trust was established in 1997 with the purpose of ensuring electricity savings in the household and public sectors. The Trust is financed by a special electricity savings charge of DKK 0.006/kWh payable by households and the public sector. The total annual proceeds amount to approximately DKK 90 million.