Summary of selected conclusions in the Danish report:

"Elforbrug i serverrum"
- - -
"Energy Consumption in Server Rooms"

Teknologisk Institut, April 2003

Selected key points translated by Gregers Reimann (Sept. 2003):

The most efficient way to cool a server is to provide the cool air evenly to all the servers through the front panel of the rack; this is done for the server room in Kolding kommune.

The observed temperature and humidity conditions in the case study server rooms were (January 26th - March 9th):

Table 1: Temperature and humidity data

Serve placement	Server room	Temperature reaching servers [°C]	Relative humidity of air reaching servers [%]
Shelves	Forbrugerstyrelsen	22.5	30-40
	Elsparefonden	24	15-30
	Skov- og Naturstyrelsen	21	35-55
Racks	Kolding kommune	23	20-32
	Miljødepartementet	18	55-70
	Miljøstyrelsen	19*	-
	Skov- og Naturstyrelsen	16	27-37
	Danmarks Miljøundersøgelser	22**	-

* spot measurement during visit
** as informed by Danmarks Miljøundersøgelser

When asked, all server producers unanimously claim that the operational conditions for servers must lie in the interval of 10-35°C and 10-80% relative humidity. But when asked what operational conditions they recommend, the intervals become much smaller, namely 20-24°C and <50% relative humidity. In practise, server rooms are normally kept within the recommended temperature interval (20-24°C), while nobody typically worried about controlling the relative humidity level. The people that purchase servers are typically not interested in the energy consumption but rather the reliability of operation. Thus, the recommended temperature levels (20-24°C) are strictly observed (se for example Table 1).

A buffer up to the maximum air temperature of 35°C is recommended to prevent the servers from closing down at the slightest irregularity in the cooling supply.

Some key energy benchmarking data from the case studies are given in the table below:

Table 2: Key energy data for

Server room	Users [no.]	Electricity consumption pr. kWh heat load [kWh/kWh]	Useful cooling efficiency [-]	Electricity consumption pr. user [kWh/user]	Electricity consumption for servers pr. user [kWh/user]	Heat load compared to room size [kW/m^3]
Kolding kommune	1650	0.45	2.24	40.6	90.9	0.23
Miljødepartementet	150	0.6	1.67	156	260	0.06
Forbrugerstyrelsen	120	-	-	-	167	0.04
Skov- og Naturstyrelsen	1470	0.43	2.32	51	118	0.09
Elsparefonden	7	-	-	-	570	0.02

The power consumption in a server room pr. user decreases as the number of users becomes larger (see Figure 1).

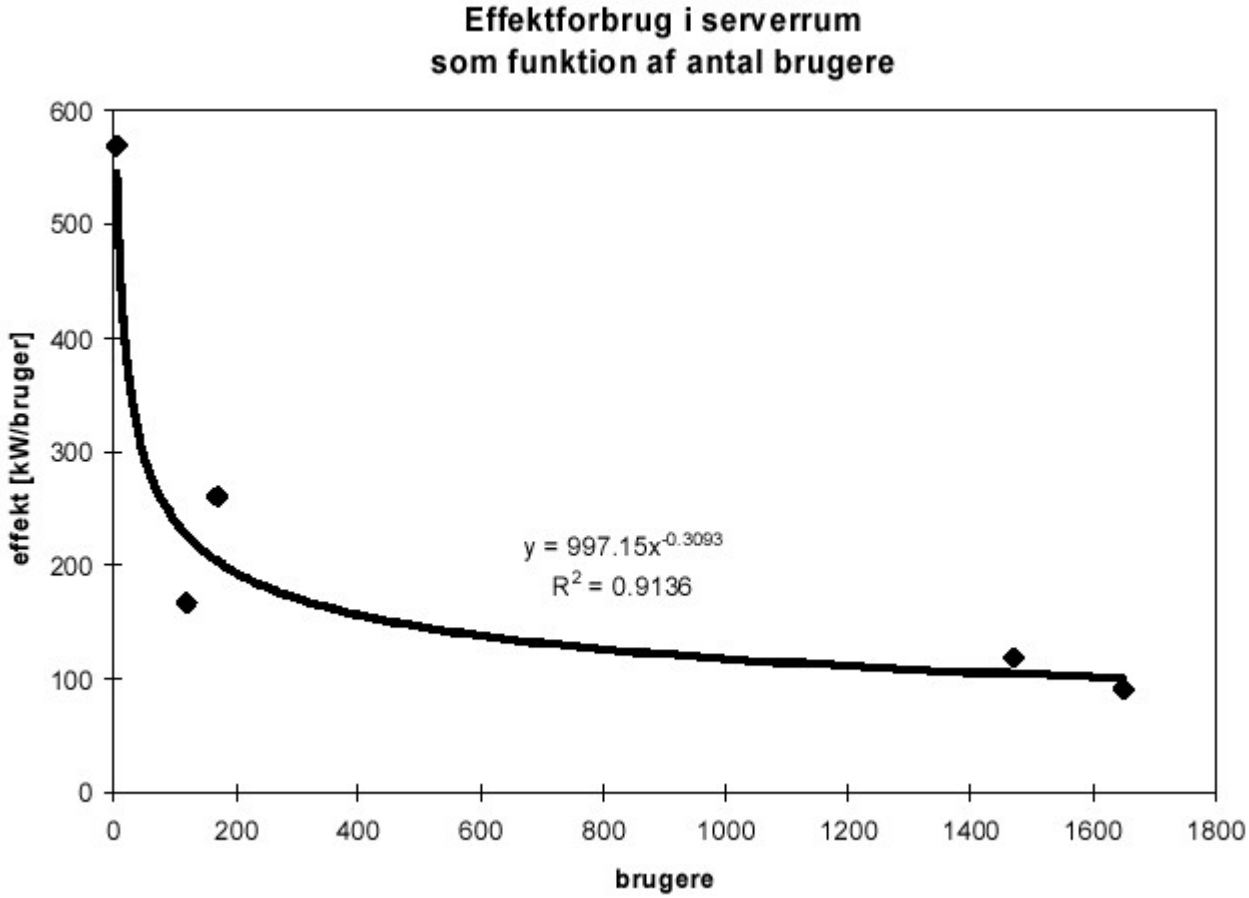

Figure 1: Title "Power in server rooms as a function of users"; y-axis "Power [kWh / user]"; x-axis "users"

In Denmark, the outdoor air can be used directly to cool the server room most of the year. This study, however, does not contain any practical examples of that.

A server room energy simulation tool was developed using the EES (Engineering Equation Solver) software. Different parameter variations were undertaken and the following conclusions were drawn, though they do not apply in a general sense for all server rooms:

- increasing the air temperature reaching the evaporator of the cooling plant will save 1-2% energy
- a reduction of the heat load by 1 kWh will result in a reduction of the cooling consumption by 0.2-0.25 kWh
- using outdoor air directly for cooling can save 25-40% energy
- on/off control of the indoor fan as opposed to constantly running the fan can save 15-60% depending on how big the fan is in relation to the heat load in the server room
- placing the condenser of the cooling plant at a higher air temperature than the outdoor air temperature increases the cooling consumption. For example, a 15°C higher air temperature at the condenser will increase the cooling consumption by 22%

Please note, that the above-mentioned savings should be compared with the cost of implementing them.

On the basis of this report it is estimated that it would be possible to reduce the energy consumption in the server rooms with 30% solely by replacing the servers with more energy efficient ones (especially the power supply and fans). This would yield a saving in the cooling consumption of 15%, as less heat is generated. (Moreover, turning off servers, sleep-mode, reduction of the clock frequency, better chips would increase the savings even more). Organising the server rooms better would yield an additional saving of 15%, e.g. by providing the evaporator of the cooling plant with a higher air temperature and by improving the cooling plant operation. If cooling by outdoor air also can be effectuated, it is estimated that the electricity for cooling can be reduced with at least 50%.

In other words, it is estimated that the heat load can be reduced by 30% and that the cooling load can be reduced by 50%.