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Potential for reducing electricity consumption by switching off servers

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This study has been carried out on behalf of the Federal Office of Energy. The contents and conclusions are the sole responsibility of the author.

Contents

1 Summary

This study concerns servers in the low-end market segment (price range up to approximately CHF 30,000). Servers of this type are primarily used in small and medium-sized companies. Experts in the field expect the use of this type of server to become more widespread in the future, since they are also being designed for use as file-, print-, Internet-access and applications servers by smaller workgroups. Approximately 47,000 servers were sold during 2001 in the low-end segment. Experts in the field estimate that the number of servers in use in Switzerland is between 150,000 and 180,000. These figures have also been confirmed in a projection resulting from a representative survey on the use of servers conducted among 400 companies in the German-speaking area of Switzerland. According to a projection by number of employees, it is estimated that approximately 117,000 servers are in use in small and medium-sized companies in Switzerland (with up to 250 employees).

According to our own measurements and those cited in specialised literature, the power consumption of low-end servers is between 80 and 150 W, depending on hardware configuration. Thanks to a survey conducted among 400 companies in the German-speaking area of Switzerland, we now have a fairly accurate picture concerning the extent of the use of network servers and their associated infrastructure, as well as the periods during which they are switched on. In the majority of cases, the supply of electricity to servers is secured via uninterruptible power supply systems, and most servers are kept in an air-conditioned environment, and of course these devices also consume electricity. The electricity demand in Switzerland for servers and their associated infrastructure is estimated at somewhere in the region of 210 GWh per annum. If servers were to be switched off overnight and at weekends (taking the utilisation by backup and communication services at certain times into account: according to the survey, 57% of the servers are only used for a maximum of three hours at night), then the potential reduction of electricity consumption would be around 90 GWh per annum. This estimate is based on the assumptions that uninterruptible power supply units are also switched off, and power consumption for air-conditioning systems is reduced.

This identified potential is currently not being exploited, since certain technical requirements are lacking and there are still various obstacles to be overcome. Some of these are listed below (though this list is probably not complete, i.e. when these obstacles have been eliminated this does not automatically mean that the identified potential will then be fully utilised):

Product development	Hardware components, including drivers and BIOS, are not ACPI[1]-compatible
Marketing	Server manufacturers sell their products with the message: available 24 hours a day, seven days a week
Choice by consumers	- There are no energy or environment labels for servers - Alongside other decision-making criteria such as reliability, security, cost/benefit ratio or confidence placed in the manufacturer, electricity consumption is of secondary importance to consumers - Decision-makers (management in small to medium-sized companies, IT specialists in larger companies), are not aware of the correlations between reliability/security and electricity consumption

[1] Advanced Configuration and Power Management Interface

Consumer behaviour

- Electricity prices do not incorporate external environmental factors. This means that they only account for a very low proportion of operating costs
- Users are not aware of correlations between reliability/security and electricity consumption

In order to increase efficient electricity use in servers, the following measures are proposed which include preliminary work aimed at technological development, suggestions for eliminating the various obstacles and proposals for providing incentives:

Measure	Players/target groups	Primary objective	Ultimate objective	Costs for achieving primary objective [CHF]
Support for introducing on/off switching systems onto the market	Manufacturers of auxiliary systems / decision-makers in small & med.-sized companies	Introduction onto market	50% of servers in small & med.-sized companies to be switched off when not in use (saving in Switzerland, approx. 45 GWh p.a.)	200,000.-
Specification of power management in product description	Buyers	Model specification	Buyers to demand power management specification in product description	5,000.-
Power management in servers: definition of principles for benchmarks	Research centres, devpt. & marketing, server manufacturers	Def. of principles for power management / further techn. devpt. of servers	Manufacturers to incorporate stand-by function (ACPI specifications) and market it	140,000.-
Communication concept for promotion of use of ACPI in servers (prerequisite: standard integration of ACPI functionality in all servers)	Decision-makers at small & med.-sized companies	Decision-makers at small & med.-sized companies to be aware of use and benefits of ACPI in servers	ACPI to be also be used in servers, i.e. servers switch into stand-by mode: (if measure concerning on/off switching system not imple-mented: saving in Switzerland, approx. 36 GWh p.a.)	100'000.-
Service life and performance of servers	Research centres; decision-makers at small & med.-sized companies	Better awareness of behaviour of service life and reliability of servers when switched off	To increase the degree of readiness to switch servers off	100,000.-
Uninterruptible power supply systems: support for EU discussion on energy label	EU authorities	EU to further develop Switzerland's preliminary work	EU to launch label, declaration requirements or agreement with manufacturers of UPS systems	75,000.-
Planning aid for air-conditioning of server rooms	Heating, ventilation & air-conditioning planners	Planning aid as flyer or web document	Air-conditioning systems to be designed and operated for max. energy efficiency	40,000.-

2 Abstracts

2.1 Stromeinsparpotential durch Schalten von Servern

Diese Studie behandelt Server im sogenannten Low-end-Marktsegment. Branchenexperten schätzen, dass der Serverbestand in der Schweiz etwa zwischen 150'000 und 180'000 Stück liegt. Davon sind 117'000 Server in Klein- und Mittelbetreiben (KMU) installiert.
Die elektrische Leistung von Low-end Server liegt gemäss eigenen Messungen und Literaturangaben je nach Ausrüstung zwischen etwa 80 und 150 W. Die Stromspeisung der meisten Server wird durch eine USV-Anlage abgesichert und der Raum, in dem sich der Server befindet wird häufig klimatisiert. Auch diese Infrastruktur benötigt Strom. Es kann ein Strombedarf für die Schweiz für die Server in KMU-Betrieben und der zugehörenden Infrastruktur berechnet werden, welcher etwa 210 GWh pro Jahr beträgt. Falls die Server in Zeiten der Nichtbenutzung (keine aktive Nutzung wie Zugriff, Backup, Kommunikationsdienste usw.) während der Nacht und am Wochenende ausgeschaltet würden, ergäbe sich ein Stromverbrauchsreduktionspotenzial von etwa 90 GWh pro Jahr.
Um die Stromeffizienz in Servern zu steigern werden Massnahmen vorgeschlagen, welche Vorarbeiten zur Technikentwicklung und Vorschläge zum Abbau von Hemmnissen und zum Aufbau von Anreizen beeinhalten:

- Unterstützung Markteinführung Ein-/Ausschaltsystem
- Spezifikation des Powermanagements in Ausschreibungen
- Powermanagement in Server: Grundlagen für Benchmarks erarbeiten
- Kommunikationskonzept für die Förderung des Einsatzes von ACPI (Advanced Configuration and Power Management Interface) in Server
- Kenntnisse verbessern über Lebensdauer und Verfügbarkeit von Servern
- USV-Anlagen: Labeldiskussion in EU unterstützen
- Planungshilfe für die Kühlung von Server-Räumen

2.2 Potential for reducing electricity consumption by switching off servers

This study concerns servers in the low-end market segment. Experts in the field estimate that the number of servers in use in Switzerland is between 150,000 and 180,000, of which around 117,000 are installed in small and medium-sized companies.
According to our own measurements and those cited in specialised literature, the power consumption of low-end servers is between 80 and 150 W, depending on hardware configuration. In the majority of cases, the supply of electricity to servers is secured via uninterruptible power supply systems, and most servers are kept in an air-conditioned environment. And of course these devices also consume electricity. The electricity demand in Switzerland for servers and their associated infrastructure in small and medium-sized companies is estimated at somewhere in the region of 210 GWh per annum. If servers were to be switched off during periods of inactivity (i.e. no active use such as access, backup, communication services, etc.) overnight and at weekends, then the potential reduction of electricity consumption would be around 90 GWh per annum.
In order to increase efficient electricity use in servers, measures have been proposed which include preliminary work aimed at technological development, suggestions for eliminating the various obstacles and proposals for providing incentives:

- Support for introducing switching systems onto the market

- Specification of power management in servers
- Power management in servers: definition of principles for benchmarks
- Communication concept for promotion of the use of ACPI (Advanced Configuration and Power Management Interface) technology in servers
- Better awareness of service life and reliability of servers
- Uninterruptible power supply systems: support for EU discussion on energy label
- Planning aid for air-conditioning of server rooms

2.3 Economies potentielles d'électricité grâce à la mise hors tension des serveurs

Cette étude se penche sur les serveurs du segment low-end du marché. Les experts estiment qu'il y a en Suisse entre 150 000 et 180 000 serveurs. 117 000 d'entre eux sont installés dans des petites et moyennes entreprises (PME).
Ces serveurs low-end consomment, selon les mesures faites par les entreprises et les caractéristiques reprises dans les modes d'emploi, entre 80 et 150 W en fonction de leur équipement. La plupart des serveurs sont en outre protégés par un système d'alimentation ininterrompue en courant et la pièce dans laquelle ils se trouvent est souvent climatisée. Cette infrastructure nécessite elle aussi de l'électricité. La consommation électrique des serveurs installés dans les PME suisses et de l'infrastructure correspondante s'élève à environ 210 GWh par an. Il serait possible, en mettant les serveurs hors tension pendant les périodes de non-utilisation (absence d'utilisation active telle qu'accès, sauvegarde, services de communication, etc.) pendant la nuit et le week-end, de réduire cette consommation d'électricité d'environ 90 GWh par an.
Les mesures suivantes, soutenues par des travaux préliminaires sur l'évolution technique et des propositions visant à éliminer les obstacles et à créer des incitations, sont proposées pour optimiser la consommation d'électricité des serveurs :

- Soutien de l'introduction sur le marché d'un système de mise sous/hors tension
- Gestion de l'alimentation dans les serveurs : élaboration de bases pour des tests comparatifs
- Spécification de la gestion de l'énergie dans les demandes d'offre
- Concept de communication dont le but est d'encourager l'utilisation de l'interface ACPI (Advanced Configuration and Power Management Interface) dans les serveurs
- Amélioration des connaissances sur la durée de vie et la disponibilité des serveurs
- Systèmes d'alimentation ininterrompue en courant : soutien de la discussion sur les labels au sein de l'UE
- Aide à la planification pour le refroidissement des salles des serveurs

3 Introduction

Data processing servers are in operation round the clock, even though in many cases server facilities are not needed during the night or on weekends. A representative market study has shown that the typical small or medium-sized company in German-speaking Switzerland would be in favour of automatic switching-off of servers during certain times if advanced, reliable systems for this purpose were available.
The technical and organisational feasibility of switching servers has been demonstrated in four pilot systems that have undergone continual development:

- Switching using a converted timer in a small company
- Switching with the aid of an uninterruptible power supply (UPS) system in a small company
- Switching via networked switchboxes in a large organisation within the Swiss federal administration
- Switching with an installed Linux server and networked switchboxes in a large organisation within the Swiss federal administration

The results obtained through these forms of automatic switching were as follows:

- Enhancement of reliability thanks to controlled daily shutdown
- Remote booting of system: time-saving for system managers
- Complete separation from mains network: increased IT security (prevention of unauthorised access, physical interference) during almost 50 percent of the time
- Almost 50 percent reduction in power consumption of servers

The components installed in the pilot systems are still in their prototype stage, and this means that considerable investments would be required in order to bring them onto the market.
In order to make a decision regarding future investments and how to proceed from here, it is necessary to collect data concerning the energy-saving potential in Switzerland. The question of which measures and players will help realise any such potential also has to be examined. Here we feel that it is important to include all players as well as the entire product cycle in this study.

4 Procedure, description of data set

The number of installed servers in Switzerland is calculated with the aid of sales statistics and estimated life cycles. Only a handful of sources are available, and the only way to obtain the desired statistics is to purchase them. But a closer examination has revealed that an accurate sales chart for servers, as cited in an earlier study [sch 01], does not in fact exist. Sales figures for computers are only recorded by type of processor, which means they do not provide any indication of whether the devices are used as servers or work-station computers [iha 02]. Unfortunately there are also no reliable and freely accessible data available in Switzerland concerning PC equipment at work-desks. International polling organisations usually only publish figures concerning the market shares of computer manufacturers, but seldom release absolute sales figures.
Thanks to a recent survey [gru 00], we do have information concerning behaviour in small and medium-sized companies with respect to the switching off of servers and the use of UPS and air-conditioning systems. Unfortunately this survey does not indicate the actual

size of those companies that do not have a server, nor does it state which sector they belong to.
We assume that the distribution of servers recorded in the survey [gru 00] may be regarded as representative within each sector and for companies of the same size. We can therefore use the results of the survey to make projections concerning sector and size of company for the entire country.
In order to obtain more precise figures concerning the use of servers, it would be necessary to conduct a new representative survey in which the following information needs to be requested:

- Sector in which company is active
- No. of employees
- No. of work-desks equipped with a computer
- No. of low-end servers in use (price category, < CHF 30,000)
- No. of mid-range servers in use (price category, CHF 30,000 to 300,000)
- Whether servers are used with an uninterruptible power supply device
- Whether servers are located in an air-conditioned environment

A well-known polling organisation has estimated the costs at around CHF 45,000.

5 Segmentation on the server market

A server is normally defined as a computer that is not directly and permanently operated by a given user. Servers provide a group of users with functions and services, or work in the background where they process data that are sent or requested by other computers. By comparison with a PC, a server possesses a higher level of security and reliability.
It used to be the case that computer centres were equipped with mainframes that exclusively performed the functions of a server, while mini-computers such as the DEC VAX family were used at the low end. Nowadays we usually refer to these segments as high-end and mid-range servers, and it is now frequently the case that PCs or low-end servers also perform data, printing, communication and web server functions.
The most important segmentation criteria today are security and redundancy. Server systems are commonly divided into three main categories:

- Entry, low-end, low cost, PC servers, etc.: lowest price category (<CHF 30,000); normally installed in non-critical areas and frequently in small businesses. This category normally does not include redundancies such as processors and power supply. The equipment is primarily used for data, printing, communication and web server functions.
- Mid-range, mid-sized, enterprise, etc.: price range, CHF 30,000 to 300,00; often includes redundancies with respect to critical components: dual processors, redundant power supply, hot-plug capability of disks, ventilator and memory. Primarily used for data and applications servers with moderate data volume and average demands on performance.
- High-end, enterprise, mission critical: upper price range (>CHF 300,000); devices are equipped with every available security feature: redundant components, hot-plug capability for all critical elements, scalability of performance. Mainly used for standard batch processes with high data volume, e.g. bulk processing, banking applications, reservation systems for airlines, etc.

Servers are available in two different forms:

- As stand-alone devices (similar to PC towers)

- In their own casing for installation in a rack with standardised dimensions

6 Market players

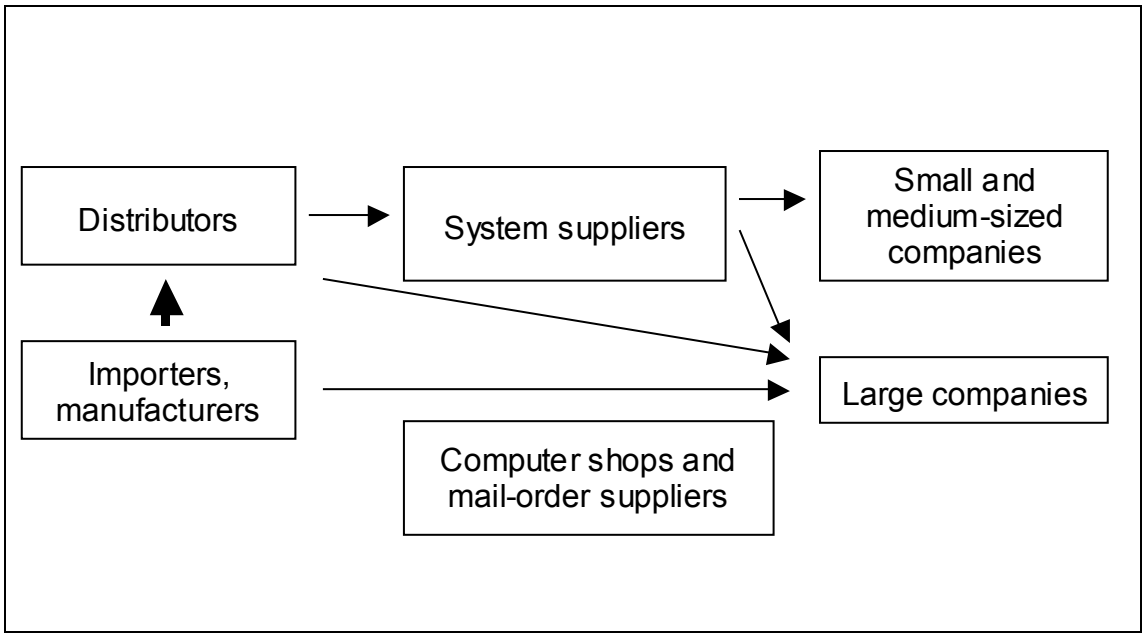

Fig. 3-2 Flow of trade on the server market

In small and medium-sized companies, decisions concerning the acquisition of electronic office and IT equipment are frequently made directly by the management. Here the criteria are:

- Reliability/security of systems
- Cost/benefit ratio
- Confidence in suppliers

In larger organisations, acquisition is normally the responsibility of the relevant specialists:

- IT department, which is responsible for specification, installation, maintenance and training. Energy consumption is usually not a consideration (lack of information, shortage of resources, no demand among users, priority given to security/reliability).
- Acquisitions: Here the decisive criterion is usually the lowest possible price.
- Environmental protection/security: These sections are responsible for ensuring compliance with the relevant laws, standards and guidelines, and with environmental/energy guidelines.

It is often the case that a request for tenders is issued before equipment is purchased. During the initial evaluation stage, care is taken to ensure that the cited technical specifications are met in full. During the second stage it is usually the price that determines which supplier receives the order.

7 Sales statistics and figures concerning the no. of installed servers in Switzerland

7.1 Work-desk computers

It is estimated that around 2.1 million work-desk computers are currently in use in Switzerland [wei 02]. And according to the same source, approximately 1.8 million devices are installed in private households. The volume of computer sales has stagnated over the past few years.

Year	Volume [in 1,000]
1996	517
1997	606
1998	729
1999	794
2000	800
2001	760
Total	4'207

Table 7-1 Sales figures for desktop computers in Switzerland over the past five years [wei 02]

The same source states that for every 100 employees in Switzerland there are approximately 73 work-desk computers.

7.2 Servers

During 2002, the sales figures for servers in Switzerland rose by 15 percent versus the prior year, to reach approximately 760 million Swiss francs. Expressed in terms of quantity, 42,700 servers were sold during 2000, compared with 47,200 in 2001 [wei 02]. This means that the average price was around CHF 16,000. The disposal rate for servers is estimated at between 15% and 20%, which is equivalent to a service life of between 5 and 7 years [wei 02a].

Another confidential source used by an international polling organisation has cited similar sales figures for servers in Switzerland. All experts in the field expect the use of low-end servers in particular to become more widespread in the future, since they are also being designed for use as file, print, Internet access and applications servers by smaller workgroups. Prices for low-end servers have fallen sharply and are now already below CHF 5,000.

The following projection is based on a representative survey that was carried out in 2000 among 400 companies in the German-speaking area of Switzerland for the purpose of gaining information about their use of servers and readiness to use automatic switch-off devices for servers. From this survey we were able to determine the number of work-stations per server. The finding was that the number of work-stations per server decreases as the number of servers installed in the company increases (cf. Table 7-2). This is probably attributable to the fact that in larger companies the number of central applications increases disproportionately.

No. of servers	No. of work-stations per server	No. of surveyed companies
1	12.8	183
2	11.2	94
3	12.0	42
4	13.3	37
5	10.6	16
6	11.0	6
7	5.8	3
8	16.8	5
10	7.3	3
11	7.3	1
12	7.2	3
15	6.1	3
20	7.0	1
22	5.7	1
25	9.0	2

Table 7-2 No. of work-stations per server

Our projection is also based on the following assumptions:

- Approximately 80% of small and medium-sized companies in the German-speaking area of Switzerland are equipped with a data processing network today [gru 00].
- - 12 work-stations per server in companies with up to 49 employees
  - 10 work-stations per server in companies with between 50 and 99 employees
  -. 7 work-stations per server in companies with more than 100 employees
  It is assumed that these figures are unlikely to vary greatly from sector to sector (more detailed analyses of the survey [gru 00] have confirmed this assumption)
- Approximately 70 work-stations per 100 employees, though this figure varies considerably from sector to sector. Overall estimate according to 2002 Weiss report [wei 02], while sector figures are based on our own estimates.

With the aid of the 1998 employment figures of the Swiss Federal Office of Statistics [bfs 98] – employees per sector and workforce per company – we have estimated the number of servers per sector and workforce (Table 7-3).

Sector	Servers in small & med.-sized companies (4 to 249 employees)	Servers in large companies (< 250 employees)
Manufacturing industry	26500	15600
Energy and water supply	1100	430
Construction	3600	240
Trade, vehicle repairs and used goods	15000	1700
Catering	3600	150
Transport and communications	7800	5700
Lending and insurance	8800	7800
Real estate, renting, IT, research and development, provision of corporate services	16000	1900
Public administration, defence, social insurance	6300	740
Education	11300	1700
Public health and social security	11700	6800
Other public and private services	5500	720
Total	117'453	43'730

Table 7-3 Estimated no. of servers per sector

The total of 161,000 servers closely matches figures cited by industry experts: based on sales figures for Switzerland, their estimate is between 150,000 and 180,000 servers [wei 02a].

7.3 Market shares of operating systems

Operating system	Market share in %
Windows	38
Linux	25
Netware	19
Unix	15
others	3
Total	100

Table 7-4 World-wide market shares of operating systems, 2000 [idc 00]

These figures should be treated with a certain degree of caution: the IDC study only includes *sold* systems. Linux operating systems that have been downloaded directly via the Internet have not been included in this study. Furthermore, it is possible to set up any desired number of servers with one copy of Linux. The fact should also be taken into account that commercial Unix servers are often used in large-scale installations in which they serve many more clients than typical NT or Linux servers. In view of this latter aspect in particular, the table would take on a significantly different appearance if it were to be based on sales rather than on the number of installations. Here, commercial Unix systems lead the field with a market share of more than 50%.

In the small to medium-sized companies segment (10 to 200 employees) in Switzerland, *Windows* is leader by a long way (cf. Table 7-5).

Operating system	Market share in %
Windows	78
Linux	3
Netware	17
Unix	17
others	14
Total	129

Table 7-5 Distribution of operating systems in small and medium-sized companies in 2000 (more than one operating system per company is possible) [gru 00]

Manufacturer	Market share in %
IBM	29
Sun	21
Compaq	14
Dell	10
Hewlett-Packard	10
others	16
Total	100

Table 7-6 Market shares of server manufacturers in the USA in the second quarter of 2001 [Source: Gartner/Dataquest]

Among purely Unix machines, Sun is leader with 44 per cent.

Manufacturer	Market share in %
IBM	16
Sun	6
Compaq	33
Dell	14
Hewlett-Packard	13
Fujitsu-Siemens	9
others	9
Total	100

Table 7-7 Market shares of server manufacturers in Europe in the first quarter of 2001 [Source: Gartner/Dataquest]

8 Potential for saving electricity by switching off servers

8.1 Power consumption

8.1.1 Servers

Measurements carried out on IBM, HP and Compaq servers have shown that the power consumption of low-end devices is between 80 and 150 W [Table 8-1]. For the purposes of this study, we took a mean level of 115 W as the basis for additional calculations.

Manufacturer	Model	Power consumption (*own measurement)[W]
IBM	xSeries230	115*
IBM	xSeries240	145
IBM	xSeries330	110*
IBM	xSeries350	135
IBM	xSeries370	1000
Hewlett-Packard	Netserver E800	80*
Hewlett-Packard	LH Pro	130*
Compaq	Proliant 1600	137*
Compaq	Proliant 370	80*
Compaq	DL320	76
Sun	Cobalt 41	34
Sun	Cobalt 4R/XTR	72

Table 8-1 Power consumption of different types of servers (Sources: own measurements, measurements by manufacturers) [rot 02]

However, the power consumption of the various servers greatly depends on their hardware configuration. Server configuration may depend on

- Number of processors
- RAM storage capacity
- Number of disks
- Number of redundant power supplies
- Number of ventilators
- Peripheral devices
- etc.

Depending on the hardware configuration, power consumption may be as much as 100 per cent higher than with the basic configuration.

8.1.2 Uninterruptible power supply (UPS) systems:

The efficiency of a UPS system depends primarily on the following factors [mau 99]:

- Type and size of system
- Type of operation (bypass, UPS operation)
- Load

In a typical system (range, 600 to 1,500 VA) the efficiency with 50% load is approx. 88-90% in dual conversion mode[2] and around 95% in bypass mode[3]. For the purpose of this study we assumed that the UPS system was being operated in dual conversion mode with an efficiency rate of 90%.
In stand-by mode, the capacity of a UPS system is around 20 W for a device with a nominal output of 600 to 1500 VA (measurement on a system from Exide Electronics, 25 W; manufacturer's specification, 17 W).

[2] Dual conversion mode: the power is fed to the device in normal operating mode via the DC/AC converter.
[3] Bypass mode: the power is fed to the device in normal operating mode directly via a static bypass (without DC/AC converters). Energy losses are at their lowest in this mode, as long as components sucvh as DC and AC converters are not switched on permanently.

8.1.3 Air-conditioning

The heat generated by the various devices has to be removed from the operating environment, and this in turn requires electricity. The actual amount depends on the following factors:

- Room temperature setting
- Type of system (full air-conditioning, ventilation, water or air as cooling medium, free-cooling option, etc.)
- Outside air temperature

Data obtained from computer centres has shown that the power requirements for cooling and ventilation are approximately the same as those for the data processing load [ene 98].

If the capacity of the air-conditioning system is reduced by the same ratio as that of the server, it is possible to double the saving in electricity consumption of the server.

8.2 Utilisation of servers

Servers are normally left on permanently, and this is encouraged by manufacturers in that they strongly emphasise the fact that these products offer a high level of security and reliability and are therefore intended for use 24 hours a day, 365 days a year. On top of this, it is often the case that personnel responsible for systems are anxious that if they switch them off they may not be able to reboot them. The frequently cited motto, "Never touch a running system", is clear evidence of this widespread attitude.

8.3 Installed systems in typical small and medium-sized companies

8.4 Servers

The designation "small and medium-sized companies" refers to businesses with less than 250 employees. We have assumed that small businesses with 3 or less employees do not use a server. Large companies are mostly active on an international scale and probably need their servers to operate 24 hours a day. For the purpose of this study we have therefore defined small and medium-sized companies as businesses with 4 to 249 employees. In this segment there are around 93,000 such companies (30 per cent of all registered businesses) in Switzerland, and 117,800 workplaces with a total of 2,308,000 employees (67% of all gainfully employed persons in Switzerland) [bfs 98].

As indicated in Table 7-2, the estimated number of servers in use in small and medium-sized companies with between 4 and 249 employees is 117,000.

8.4.1 Uninterruptible power supply (UPS) systems:

The frequency of use of USP systems is very high [gru 00]:

- 68% of companies with 1 server
- 89% of companies with 2 to 4 servers
- 98% of companies with 5 or more servers

If we multiply the figures provided by the Federal Office of Statistics (Appendix 2) with those cited above, the estimated number of installed UPS systems is 83,000. If we then compare this figure with the estimated number of installed servers (98,000), this means that 83.8% are operated with a UPS device.

8.4.2 Air-conditioning

Rooms in which servers are located are often air-conditioned:

- 24% of companies with 1 server
- 60% of companies with 2 to 4 servers
- 86% of companies with 5 or more servers

If we multiply the figures provided by the Swiss Federal Office of Statistics (Appendix 3) with those cited above, the estimated number of companies in which server rooms are air-conditioned is 35,000. If we then compare this figure with the estimated number of installed servers (65,000), this means that 55.6% are operated in an air-conditioned environment.

8.5 Reduction of operating hours

A representative survey conducted among 400 small and medium-sized companies in the German-speaking area of Switzerland concerning their effective need for network servers at night and during weekends/public holidays yielded the following findings [gru 00]:
1. The majority of those companies that are equipped with a network leave all their servers on at night (94%) and during weekends/public holidays (90%), even though approximately a quarter of all active servers do not perform any functions at all at night, and almost half have no functions to perform at weekends.
2. Roughly 2/3 of those servers that perform functions and processes at night effectively need less than three hours to complete these tasks.
3. Systems that automatically switch servers on and off would be generally welcomed: 57% of the companies participating in the survey stated that they were in favour of the option of automatically switching a server on or off at a specified time or after a specified event. The 57% concerned possess slightly more than 54% of the total of installed servers. 46% of the companies participating in the survey were in favour of the option of automatically switching off a server when it is not in use and being able to switch it back on again from the work-desk.
4. The tendency among companies to reject such options is not so much attributable to practical or technical considerations as to uncertainties, old habits and ingrained attitudes, or doubts concerning technical feasibility.

We assume that it would be possible to switch off servers that do not need to perform any functions outside of normal working hours at 8 p.m. and to switch them back on again at 6 a.m. At weekends, the period during which we assume that servers can be switched off extends from 8 p.m. Friday to 6 a.m Monday. This means that servers would be inactive for 108 hours a week out of a total of 168 (= 64%). We may assume that these periods of inactivity apply to approximately 40% of servers (according to [gru 00], around 44% of servers do not perform any functions at night and during weekends). 6% of servers are already switched off overnight and at weekends. The remaining 50% are left running, and perform certain functions from time to time, such as backups, data alignment, receipt of e-mails, etc.

Duration	Proportion of servers (%) active at night	Proportion of servers (%) active at weekends
< 1 hr	17	38
> 1 hr and < 2 hrs	21	13
> 2 hrs and < 3 hrs	19	13
> 3 hrs	32	26
No indication	11	10
Total	100	100

Table 8-2 Server activity at night and during weekends [gru 00]

Proportion of servers in %	Inactive periods per week at night (in hrs)	Remarks
14	0	Are already switched off, or no information given
31	25	Active 5 hrs per night
18	35	Active 3 hrs per night
20	40	Active 2 hrs per night
17	45	Active 1 hr per night
100		

Table 8-3 Potential additional inactive periods at night

Proportion of servers in %	Inactive periods per week during weekends (in hrs)	Remarks
17	0	Are already switched off, or no information given
24	53	Active 5 hrs per weekend
12	55	Active 3 hrs per weekend
12	56	Active 2 hrs per weekend
35	57	Active 1 hr per weekend
100		

Table 8-3 Potential additional inactive periods at weekends

If we multiply the proportions of servers with potential inactive periods as shown in Tables 8-3 and 8-4, this results in a total potential for all servers of 76 hours per week, or 3,936 hours per annum (equivalent to 45% of all hours p.a.).

8.6 Electricity savings potential

8.6.1 Theoretical savings potential

The savings in annual electricity consumption that are realisable in theory during potential periods of inactivity may be calculated as follows:

$E = \sum s * n_i * p * h$

s = no. of servers

i = category: without UPS, with UPS without air-conditioning, with UPS/with air-conditioning

n_i = proportion of servers in category i

p = mean power consumption in kW (server + UPS losses + air-conditioning)
h = potential switch-off time in no. of hours per annum
For this formula it was assumed that:

- all servers in air-conditioned rooms are also operated with a UPS device
- devices do not consume any power after they have been switched off (apparent power consumption in off mode)
- the power consumption of the air-conditioning system is reduced at the same ratio as that of the data processing system.

The savings potential is calculated using the above formula together with the following figures:

- No. of servers in small and med.-sized companies in Switzerland (Tab. 7-2) 117,000
- Proportion of servers without UPS and air-conditioning (section 8.4.1) 16.2%
- Proportion of servers with UPS but without air-conditioning (section 8.4.1) 28.2%
- Proportion of servers with UPS and air-conditioning (section 8.4.2) 55.6%
- Mean capacity of servers (section 8.1.1) 115 W
- Losses due to UPS device (section 8.1.2) 10%
- Losses due to air-conditioning system (section 8.1.3) 100%
- Potential total switch-off time (section 8.5) 3,936 hrs per annum

Our calculation using the above figures results in a theoretical potential reduction of power consumption of around **91 GWh p.a.**
If all 117,000 servers are permanently in operation, their total power requirement is around **212 GWh p.a.** Here the fact is taken into account that, during normal daily operation, the power consumption of a server is slightly higher due to the need to access disks and higher processing loads. Based on our own measurements, we estimate that this increase is around 10 percent on average. If this increased power requirement is assumed to apply for roughly half the time, the power requirement for all servers would be approximately 5 per cent higher on average.
This means that, in the case of permanent operation, the theoretical savings potential for servers would be approximately 43 per cent of the power consumption.

8.6.2 Effective electricity savings potential

The effective savings potential is undoubtedly lower than the theoretical figure, since not all server operators are prepared to switch off their systems. As stated in section 8.5 above, 57% of server operators welcome the option of automatically switching a server on or off at a specified time or after a specified event. The 57% concerned possess slightly more than 54% of the total of installed servers.
When a server is switched off, the power requirement of the air-conditioning system only decreases if the system concerned is also able to dynamically react to the reduced thermal output. If the server room is only a small part of a fully air-conditioned building, then it cannot be assumed that the reduction in output will be very high. The greatest effect is of course achieved if a small air-conditioner is responsible for the server room and the system is also switched off during the time the server is inactive.

9 International comparison

	Switzerland [Bfs 98]	EU [Eur 00]	USA [cen 97]
Population (million)	7.2 (2001)	380 (2001)	275 (2000)
Workforce (million)	3.5 (1998)	113 (1997)	87 (1992); 101 (1997)
Employees of small & med.-sized companies (million)	2.9 (1998)	74 (1997)	41 (1992);
Proportion of employees in small businesses	10% (1998) (2 to 3) 16% (1998) (4 to 9)	24%[4] (1997) (1 to 9)	7% (1992) (5 to 9)
Proportion of employees in companies with 10 to 249 employees	50% (1998)	32% (1997)	35% (1992)
Proportion of employees in companies with more than 250 employees	15% (1998)	34% (1997)	53% (1992)
No. of companies (million)	0.32 (1998)	19 (1997)	5.8 (1992) 6.4 (1997)
No. of small and medium-sized companies (million)	approx. 0.31 (1998)	approx. 19 (1997)	4.6 (1992)

Table 9-1 Comparison of various corporate and workforce factors in Switzerland, the EU and the USA

In an initial rough estimate it was assumed that the corporate, workforce and IT infrastructures in Switzerland, the EU and the USA are similar, and that the workforce is a suitable projection mulitplier. This calculation results in the following server figures:

Area	Servers in all companies (million)	Servers in small and medium-sized companies (million)
Switzerland	0.161	0.117 (73%)
EU	5.2	2.5 (47%)
USA	4.6	2 (42%)

Table 9-2 Projected server figures in the EU and the USA using workforce figures

According to a US study, the number of servers in the USD 10,000 price segment is 4.6 million [rot 02]. This figure corresponds to the above estimate. The exact match is undoubtedly coincidental, since neither procedure is especially precise, but the rough figures are probably fairly accurate. The same study cites the number of work-desk computers in the services sector at 58.6 million. Given a total of 4.6 million servers (the authors have assumed that all servers are used in the services sector), this results in 14.5 work-desk computers per server.

[4] There is also an employee category with 0 employees, and this is the reason why the total of percentages shown here for the EU does not add up to 100%.

In Western Europe, a total of 292,000 servers were sold in the first quarter of 2001 (Source: Gartner/Dataquest). If we assume that sales remained constant throughout that year, this results in an annual total of around 1.2 million servers, which is approximately 25% lower than the equivalent figure for the USA [rot 02]. Similarly, this would mean that the number of servers in the EU would be approximately 3.5 million.
If the electricity consumption data for Switzerland are projected to the EU and the USA via the estimated number of servers (Table 7-1), we obtain the following figures:

Area	Electricity consumption, servers in small and med.-sized companies [TWh/a]	Theoretical savings potential, servers in small and med.-sized companies [TWh/a]
Switzerland	0.21	0.09
EU	4.5	2.0
USA	3.6	1.6

Table 9-3 Projected electricity consumption and savings potential in the EU and the USA based on number of servers

10 Potential measures for influencing the electricity consumption of servers and their associated infrastructure

10.1 Possible reasons why the potential is not being exploited

The electricity consumption of servers only becomes one of the most important factors in a network if an optimal power management system is in use for work-desk computers, i.e. if devices are switched off when not in use at night and during weekends, and monitors are installed that use energy-efficient LCD technology. The market penetration of LCD monitors is now on the increase, so these prerequisites are frequently being met today. The potential identified in section 8.6 above is not being fully exploited, partly because certain obstacles (e.g. lack of technical prerequisites) exist among various players in the "product cycle" (Fig. 10-1). Some of these obstacles are listed below (though this list is not complete, i.e. when these obstacles are eliminated this does not automatically mean that the potential will be fully utilised):

Product development
- Hardware components, including drivers and BIOS, are not ACPI-compatible

Marketing
- Server manufacturers sell their products with the message: available 24 hours a day, seven days a week

Choice by consumers
- There are no energy or environment labels for servers
- Alongside other decision-making criteria such as reliability, security, cost/benefit ratio or confidence placed in the manufacturer, electricity consumption is of secondary importance to consumers
- Decision-makers (management in small and medium-sized companies / IT specialists in larger companies) do not recognise correlations between reliability/security and electricity consumption

Consumer behaviour
- Electricity prices do not incorporate external environmental factors. This means that they only account for a very low proportion of operating costs
- Consumers do not recognise correlations between reliability/security and electricity consumption

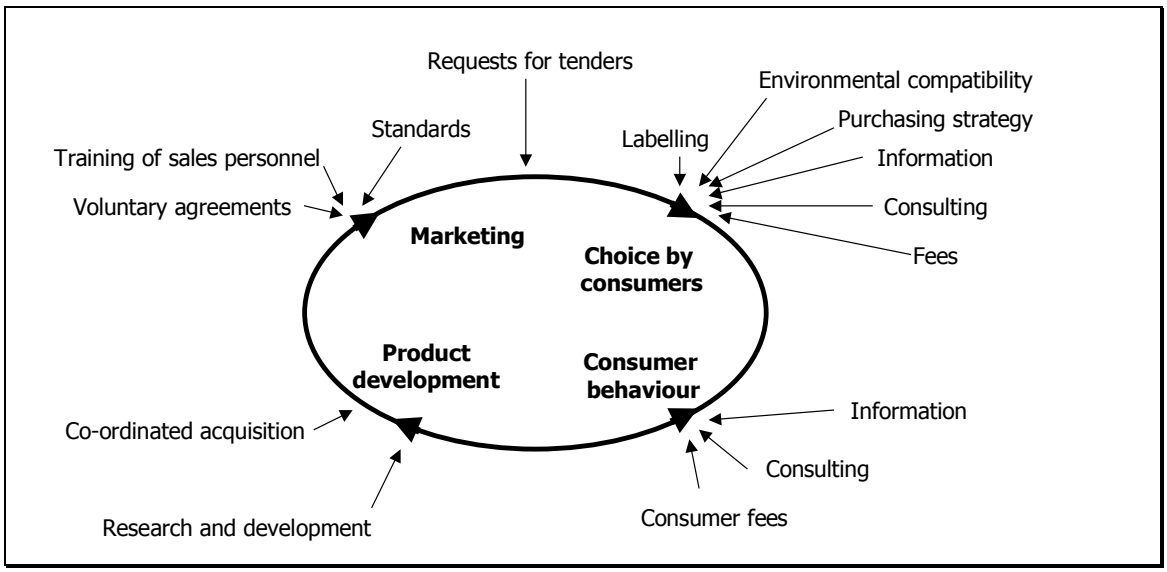

Fig. 10-1 Players and measures in the product cycle (based on a model by Lene Nielsen, Danish Energy Agency) (Source: [aeb 94])

Demand for energy-efficient technologies needs to be promoted. This should involve the following main activities:
- Information
- Standards / labels
- Co-ordinated acquisition, etc.

10.2 Support for introducing switching systems onto the market

As a survey among small and medium-sized companies in Switzerland [gru 00] revealed, a majority of the respondents welcome the option of switching servers on and off. This indicates that the market would respond positively to this function if it were to be made available. Unfortunately there are no such products currently on the market, and the question arises as to why this is the case.
Manufacturers do not integrate such functions into their servers because servers are marketed on the basis of the strategy, "always on".
The positive responses in the survey probably have to be interpreted to mean that switching functions would be welcomed if they were to be integrated into the server itself. It is not at all certain whether they would be accepted if additional devices or software have to be installed, since every additional component means more work for personnel who look after servers, and also influences the reliability of the system.
Sound sales arguments in favour of switching servers off during periods of inactivity include:
- Increased reliability (greater stability of server thanks to more frequent booting)
- Possibility of rebooting a server: for example, a data centre in Germany already offers server operation with a power management port, i.e. the socket can be switched via

the web interface. This means that users are able to reboot computers themselves if remote operation is no longer available.

- Hardware components are subjected to lower thermal loads
- Complete separation from mains network: increased IT security (prevention of unauthorised access, physical interference) during almost 50 percent of the time
- Almost 50 percent reduction in power consumption of servers

Every developer or supplier of external systems that enable users to switch servers on and off is aware of the fact that, if their product achieves success on the market, it would not be long before manufacturers of servers would start integrating it into their own products. This means that such devices have to be brought onto the market quickly and development costs need to be recovered within a very short time.
There are already devices on the market that are equipped with integrated web servers, i.e. they can be switched on and off via a network (example of such a product: Leunig GmbH in Germany, www.leunig.de). However, these systems do not yet offer the comprehensive functionality that would be required for automatically switching servers on and off during periods of inactivity (real-time clock with programmable switch-on times, issuing warnings to clients, shutting down servers before they are switched off. etc.). This means that additional products have to be developed in order to meet the requirements for switching servers on and off. The Swiss Federal Office of Energy has presented the results of the various implemented pilot projects to the industry, and has established contacts with potential manufacturers of an auxiliary system for automatically switching servers on and off. It also needs to actively support the market launch of developed products so that the risk for manufacturers can be reduced.
The use of an external device is necessary since no such functions have been integrated into servers to date. If auxiliary devices prove successful, this will exert pressure on server manufacturers to adopt this function and integrate it into their products.
If a product of this type is successfully brought onto the market and users really use it to switch servers off during periods of inactivity (after a product has been successfully launched, efforts still have to be made to ensure that it is also widely used), then it is conceivable that perhaps half the servers in small and medium-sized companies would be switched off when not in use. As stated in section 8.6 above, the savings in electricity consumption would be 91 GWh per annum, and if we multiply this by a factor of 0.5 (= assumed 50% of servers), we obtain a figure of approximately 45 GWh p.a.

10.3 Specification of power management in product description

If the public sector (federal government, cantons and municipalities) were to include the requirement for power management in its requests for tenders, this would quickly put pressure on system suppliers to integrate such technologies into servers. A power management specification might incorporate the following aspects:

- Integrated power management: compliance of entire system with ACPI standard
- Monitors: LCD technology
- Configuration of UPS system to suit effective requirements
- etc.

A model text would need to be formulated for this purpose.

10.4 Power management in servers

In Personal Computers that support ACPI specifications[5] (originally launched by Intel, Microsoft and Toshiba), an integrated power management system automatically switches the device into stand-by mode when it is not in use. ACPI comprises a variety of elements (cf. Fig. 10-2 below) that need to be optimally aligned. This means that the following components have to be ACPI-compatible:

- Drivers for hardware components
- BIOS software
- Motherboard hardware and software
- Operating system software

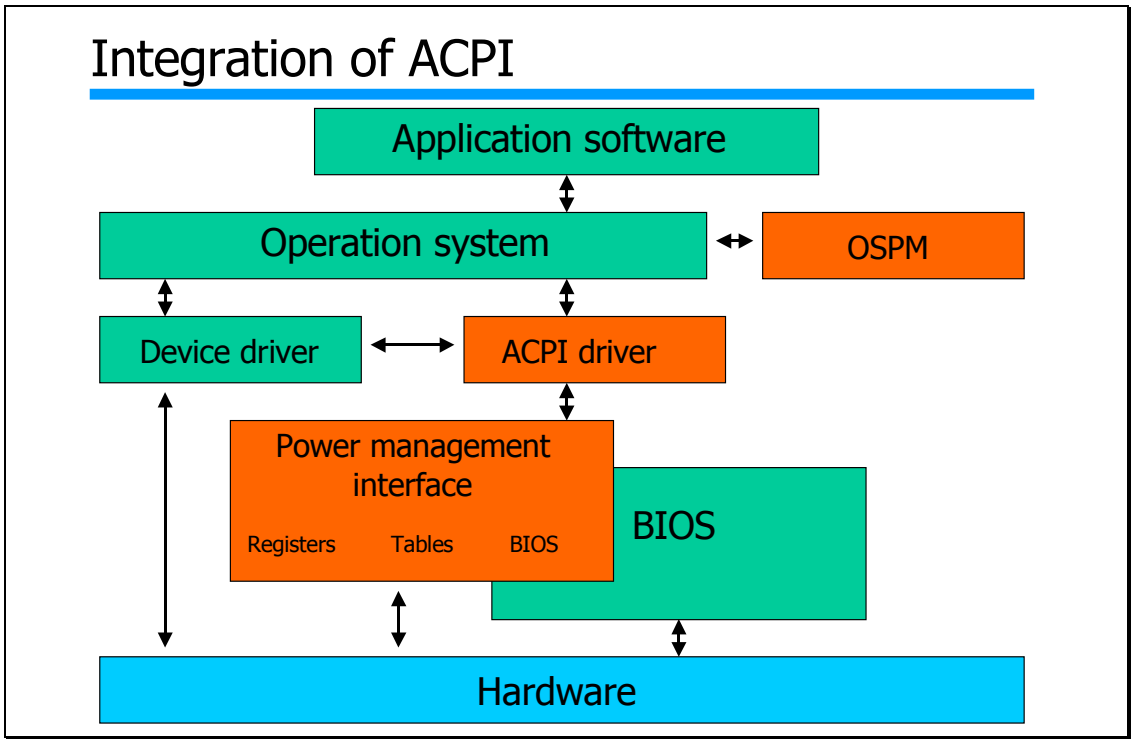

Fig. 10-2 Integration of ACPI into a system

For use with servers, ACPI is implemented in the Windows operating system (Windows 2000 and later versions). Unfortunately there are practically no hardware component drivers available on the market that support ACPI; and the same applies to BIOS software. While the requisite know-how and technology certainly exist, manufacturers have not developed the necessary products since they are not willing to do so and are not being placed under sufficient pressure by the market. In view of this situation, it is important to strengthen demand for power management from the market. This could be supported in the form of information campaigns and by providing buyers with convincing arguments. Server manufacturers are basically interested in installing stand-by functions in servers [brü 02]. The industry would like to see standardised benchmarks so that it would be able to use strong sales arguments on the market and make direct comparisons between products [brü 02]. This calls for the formulation of certain fundamentals:

- Classification of servers (low-end, mid-range, high-end, mission critical) and functional criteria (file, web, terminal, storage) according to market segment

[5] Advanced Configuration and Power Management Interface

- Interactions between functions and components (i.e. which components are needed when, and for which functions)
- Potential reference specifications and load cycles
- Measurement procedures

The best solution would be for these fundamentals to be formulated by a special workgroup comprising international researchers and manufacturers.
If manufacturers should start supplying servers with fully integrated ACPI functionality at some time in the future, it would also be important to make sure that it is actually put into use. This would call for the initiation of education and incentive campaigns. If these were to be successful, and as a result perhaps 50% of servers were to be switched to stand-by mode during periods of inactivity, then the estimated savings in electricity consumption in Switzerland would be as follows (assuming that no on/off switching system were to be brought onto the market and put into use as outlined in section 10.2 above):
80% of the theoretical savings potential as calculated in section 8.6 above for switching off servers = approximately 73 GWh per annum. For 50% of servers, this figure has to be multiplied by a factor of 0.5 (assumed 50% of servers), which results in a total of around 36 GWh per annum.

10.5 Service life and reliability of servers

Reductions in electricity costs may be considerable, but for many companies they are negligible in comparison with other operating costs associated with IT systems (maintenance and servicing of hardware and software, licence costs, etc.). Nowadays, most companies depend on the highest possible degree of system stability, and this means that disruptions to their IT systems can be extremely costly. Therefore the best way to sensitise companies is probably via arguments concerning reliability, disruption probability and service life of IT systems. Power consumption, the question of thermal load of components, operating time, frequency of switching on and off, and probability of disruptions are all interdependent. The crucial question here is: if a server is switched off during periods of inactivity, will this lessen the likelihood of a disruption and extend its service life? Or to formulate this question from another angle: to what extent is the service life of components that are subject to mechanical wear and tear (e.g. fans) affected by switching a server off during periods of inactivity, and are electronic components subjected to lower thermal loads? These questions need to be carefully studied at an institute of technology.

10.6 Uninterruptible power supply (UPS) systems: support for EU discussion on energy label

In addition to measures directly relating to servers, it is also important to promote efficient energy use in the areas of uninterruptible power supply devices and air-conditioning systems. With respect to UPS systems a quality matrix, measuring methods and an energy label have been defined [mau 98] with the support of the Federal Office of Energy. We should now endeavour to bring these findings into international discussions concerning the introduction of an energy label.

10.7 Planning aid for air-conditioning of server rooms

With respect to the cooling of servers with the aid of air-conditioning and ventilation systems, the following measures can have a positive influence on power consumption [aeb 02]:

- Use of free cooling
- Increasing the room temperature to 26° C [eis 95]
- Increasing the cold-water temperature from 6° C to 11-13° C
- Optimising the flow of air into the computer room with slow air speeds (approx. 1.5 metres per sec.)

A suitable controlling system (e.g. measurement and observation of an energy-efficiency factor [aeb 02]) would help optimise the operation of the various systems. These measures have not yet been perceived by all planners, so it would be useful to prepare a basic planning aid.

10.8 Summary

The table below provides an overview of the seven measures proposed in this report:

Measure	Players/target groups	Primary objective	Ultimate objective	Costs for achieving primary objective [CHF]
Support for introducing on/off switching systems onto the market	Manufacturers of auxiliary systems / decision-makers in small & med.-sized companies	Introduction onto market	50% of servers in small & med.-sized companies to be switched off when not in use (saving in Switzerland, approx. 45 GWh p.a.)	200,000.-
Specification of power management in product description	Buyers	Model specification	Buyers to demand power management specification in product description	5,000.-
Power management in servers: definition of principles for benchmarks	Research centres, devpt. & marketing, server manufacturers	Def. of principles for power management / further techn. devpt. of servers	Manufacturers to incorporate stand-by function (ACPI specifications) and market it	140,000.-
Communication concept for promotion of use of ACPI in servers (prerequisite: standard integration of ACPI functionality in all servers)	Decision-makers at small & med.-sized companies	Decision-makers at small & med.-sized companies to be aware of use and benefits of ACPI in servers	ACPI to be also be used in servers, i.e. servers switch into stand-by mode: (if measure concerning on/off switching system not implemented: saving in Switzerland, approx. 36 GWh p.a.)	100,000.-
Service life and reliability of servers	Research centres; decision-makers at small & med.-sized companies	Better awareness of behaviour of service life and reliability of servers when switched off	To increase the degree of readiness to switch servers off	100,000.-
Uninterruptible power supply systems: support for EU discussion on energy label	EU authorities	EU to further develop Switzerland's preliminary work	EU to launch label, declaration requirements or agreement with manufacturers of UPS systems	75,000.-
Planning aid for air-conditioning of server rooms	Heating, ventilation & air-conditioning planners	Planning aid as flyer or web document	Air-conditioning systems to be designed and operated for max. energy efficiency	40,000.-

Table 10-1 Potential measures

11 Recommendations, next steps

We recommend distributing an English version of this report to an international public. List of most important recipients:

- Server manufacturers
- Manufacturers of server components
- Manufacturers of software in the areas of BIOS and operating systems (Windows, Unix, Linux, Mac-OS)
- Manufacturers of uninterruptible power supply systems
- Authorities issuing energy and environment labels
- Governmental and non-governmental energy agencies
- IT heads at large companies

A simplified version should be distributed to decision-makers (management staff) at small and medium-sized companies.

We also recommend initiating the activities proposed in section 10 with the aim of achieving widespread use of power management systems in servers in the future. This would mean that servers would be switched to stand-by mode (= low power consumption) during periods of inactivity at night and during weekends, or switched off completely.

In view of the chances for success in the short term and an optimal cost/benefit ratio, we propose that the highest priority should be attached to implementing the following measures:

- Support for introducing switching systems onto the market
- Specification of power management in servers
- Better awareness of service-life and performance of servers
- Uninterruptible power supply systems: support for EU discussion on energy label
- Planning aid for air-conditioning of server rooms

If the public sector (federal government, cantons and municipalities) were to include the requirement for power management in its requests for tenders, this would quickly put pressure on system suppliers to integrate such technologies into servers. A model text would need to be formulated for this purpose.

12 References

[aeb 94] Aebischer Bernard et al.: Market-Pull Report, ETH Zürich im Auftrag des Bundesamtes für Energie / *Market-pull report, Federal Institute of Technology, Zurich, on behalf of the Federal Office of Energy*

[aeb 02] Aebischer Bernard et al.: Energy- and Eco-Efficiency in Data Centres, CEPE, ETH Zurich, 2002

[bec 01] Beck Fred, Energy smart data centres: applying energy efficient design and technology to the digital information sector, Renewable Energy Policy Project, Washington, 2001

[bfs 98] Bundesamt für Statistik: Arbeitsstätten und Beschäftigte nach Beschäftigungsgrössenklassen und Branchen gemäss „Allgemeine Systematik der Wirtschaftszweige (NOGA)", Bern 2001 / *Federal Office of Statistics: Workplaces and employees by company size and sector in accordance with the NOGA general business sector systematics, Berne 2001*

[brü 02] Roland Brüniger: Impact of Information & Communication Technology on the Energy System. Conference report. IEA, 21-22 February 2002, Paris

[cen 97] U.S. Census Bureau: Economic Census, Comparative Statistics, 1997

[eis 95] Eisenhut Hans et al.: Risikofreier Betrieb von klimatisierten EDV-Räumen bei 26° C Raumtemperatur, im Auftrag des Bundesamtes für Energie, Bern, 1995 / *Risk-free operation of air-conditioned computer rooms with an ambient temperature of 26° C, on behalf of the Federal Office of Energy, Berne, 1995*

[ene 98] Energieeffizienz in 15 Rechenzentren der Schweiz: ERFA-Gruppe von 5 Firmen, Zürich, 1998 / *Energy efficiency in 15 computer centres in Switzerland: ERFA group of 5 companies, Zurich, 1998*

[eur 0] Eurostat: KMU-Statistiken, Europäische Gemeinschaft, Luxemburg, 2000 / *Statistics concerning small and medium-sized companies, European Community, Luxembourg, 2000*

[gru 00] Gubler, Michael and Matthias Peters: Servernutzung in Klein- und Mittelbetrieben: Eine empirische Untersuchung zum effektiven Bedarf von Netzwerk-Servern in der Nacht und an Wochenenden/Feiertagen in Klein- und Mittelbetrieben in der Deutschschweiz; IPSO – ein Kompetenzzentrum der IHA-GfM im Auftrag des Bundesamtes für Energie, Bern, September 2000 / *Use of servers in small and medium-sized companies: an empirical study on the effective need for network servers at night and during weekends/public holidays in small and medium-sized companies in the German-speaking area of Switzerland; IPSO – a competence centre of IHA-gFM on behalf of the Federal Offce of Energy, Berne, September 2000*

[hus 99] Huser Alois: Schalten von Servern, Pilotanlage in einem KMU-Betrieb; im Auftrag des Bundesamtes für Energie, Publikation 805.089.7d, Bern; November 1999 / *Switching servers, pilot installation in a small business; on behalf of the Federal Office of Energy, Publication 805.089.7d, Berne, November 1999*

[iha 02] IHA-GfK Hergiswil, verbal information, January 2002

[idc 00] Survey conducted by International Data Corporation (IDC): www.idc.com

[kun 97] Kunz M., Kistler M.: Energieverbrauch von Netzwerkkomponenten, Basler&Hofmann und Teleinform AG, im Auftrag des Bundesamtes für Energie, 1997 / *Energy consumption of network components, Basler&Hofmann and Teleinform AG, on behalf of the Federal Office of Energy, 1997*

[mau 99] Mauchle Peter, Gilbert Schnyder: Kenngrössen für die Wahl von USV-Anlagen, in VSE-Bulletin 17/99, Zürich 1999 / *Key criteria for the selection of UPS systems, in VSE-Bulletin 17/99, Zurich 1999*

[mau 98] Mauchle Peter, Gilbert Schnyder: Parameteridentifikation und Messverfahren für USV-Anlagen, Schnyder Ingenieure AG im Auftrag des Bundesamtes für Energie, Bern 1998 / *Identification of parameters and measurement procedures for UPS systems, Schnyder Engineering, on behalf of the Federal Office of Energy, Berne 1998*

[mit 01] Mitchell-Jackson, J.D: Energy needs in an Internet economy: A closer look at data centres, University of California, Berkeley, 2001

[rot 02] Roth, Kurt W. et al.: Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings, Arthur D. Little, Inc, Cambridge, USA, 2002

[sch 01] Schaltegger Björn, Meyer & Schaltegger AG: Machbarkeitsstudie Datenerhebung im Programm "Elektrizität" Verbrauchergruppen: Unterhaltungselektronik und Büro- und Kommunikationsgeräte, im Auftrag des Bundesamtes für Energie, Bern, 2001 / *Feasibility study on data collection in the "Electricity" consumer groups programme: consumer electronics and office and communication equipment, on behalf of the Federal Office of Energy, Berne, 2001*

[wei 02] Weiss Robert: IT-Marktreport Schweiz, 13. Auflage, Männedorf, 2002 / *IT market report for Switzerland, 13th edition, Männedorf, 2002*

[wei 02a] Weiss Robert: personal message, Männedorf, 2002

Appendices

1. Projected no. of work-stations and servers per sector and by company size

Employees per workplace	MANU-FACTURING INDUSTRY	ENERGY & WATER SUPPLY	CON-STRUC-TION	TRADE; VEHICLE REPAIR & CONSUMER GOODS	CATERING	TRANSPORT AND COMMUNI-CATIONS	LENDING AND INSURANCE	PROVISION OF SERVICES TO TO COMPANIES	PUBLIC ADMINISTRA-TION; DEFENCE AND SOCIAL INSURANCE	EDUCA-TION	PUBLIC HEALTH & SOCIAL SECURITY	PROVISION OF OTHER PUBLIC & PRIVATE SERVICES	Total
	D	E	F	G	H	I	J	K	L	M	N	O	
WS employees	0.7	0.7	0.2	0.5	0.3	0.7	1	1	0.7	1	0.7	1	
WS small businesses (< 4)	36,366	670	7,988	82,571	15,718	16,003	11,814	109,245	9,393	38,474	53,141	59,383	440,765
WS mid-size businesses (4 <	317,043	12,791	48,724	202,070	50,683	98,674	107,365	215,931	80,851	156,024	145,932	75,977	1,512,064
WS large companies (> 250)	136,867	3,828	2,067	14,491	1,319	50,095	68,031	16,890	6,485	14,672	59,597	6,324	380,665
WS total	490,276	17,289	58,779	299,132	67,720	164,772	187,210	342,066	96,728	209,170	258,670	141,684	2,333,494
4-9	2,898	76	809	4,273	1,332	1,180	986	4,797	991	2,617	1,957	2,037	23,951
10-19	2,845	106	760	2,615	864	1,166	1,184	3,198	1,062	2,889	1,492	981	19,161
20-49	4,672	211	896	3,067	692	1,692	1,731	2,972	1,459	2,799	2,385	1,018	23,596
50-99	5,363	257	581	2,263	307	1,432	1,649	2,016	995	1,364	1,969	644	18,839
100-199	8,336	256	436	2,368	322	1,781	2,509	2,415	1,494	1,299	3,142	605	24,964
200-249	2,381	164	76	426	81	529	717	584	305	346	724	240	6,574
Total, small/med.sized companies	26,496	1,071	3,558	15,013	3,598	7,780	8,777	15,981	6,305	11,314	11,668	5,525	117,085
Proportion, sector [%]	23	1	3	13	3	7	7	14	5	10	10	5	100
250-499	7,283	225	165	1,022	82	1,459	1,996	1,117	637	346	2,623	292	17,246
500-999	4,673	104	71	634	69	2,111	1,985	477	104	278	1,490	262	12,259
1000+	3,686	109	0	0	0	2,155	3,794	337	0	1,052	2,698	169	14,000
Total, large companies	15,642	437	236	1,656	151	5,725	7,775	1,930	741	1,677	6,811	723	43,505
Total, all companies	42,137	1,508	3,794	16,669	3,749	13,505	16,552	17,911	7,047	12,991	18,479	6,247	160,589
Proportion, sector [%]	26	1	2	10	2	8	10	11	4	8	12	4	100

Criteria/explanations

WS = work-stations (PCs) in company

Proportion of companies with server(s)	0.80	No. of WS/server 100 to 249 empl.	7
No. of WS/server up to 49 employees	12		

2. Projected no. of companies with UPS systems per sector and by company size

Employees per workplace	MANU-FACTURING INDUSTRY	ENERGY & WATER SUPPLY	CON-STRUC-TION	TRADE; VEHICLE REPAIR & CONSUMER GOODS	CATERING	TRANSPORT AND COMMUNI-CATIONS	LENDING AND INSURANCE	PROVISION OF SERVICES TO TO COMPANIES	PUBLIC ADMINISTRA-TION; DEFENCE AND SOCIAL INSURANCE	EDUCA-TION	PUBLIC HEALTH & SOCIAL SECURITY	PROVISION OF OTHER PUBLIC & PRIVATE SERVICES	Total
	D	E	F	G	H	I	J	K	L	M	N	O	
Degree of installation													
4-9	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
10-19	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
20-49	0.89	0.89	0.68	0.68	0.68	0.89	0.89	0.89	0.89	0.89	0.89	0.89	
50-99	0.98	0.98	0.89	0.89	0.89	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
100-199	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
100-249	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
No. of companies with UPS													
4-9	6,051	156	6,360	11,861	5,938	2,332	1,414	6,521	1,789	1,880	2,401	2,543	49,247
10-19	2,653	105	2,687	3,136	1,754	976	777	1,678	899	1,062	666	534	16,927
20-49	2,577	121	1,488	1,612	661	856	673	915	764	627	730	349	11,371
50-99	1,216	60	462	569	147	313	243	266	218	135	282	80	3,990
100-199	664	21	140	240	59	138	129	119	119	51	164	32	1,876
200-249	118	8	15	26	9	23	25	20	15	8	25	7	296
Total	13,279	470	11,151	17,444	8,568	4,638	3,261	9,517	3,803	3,762	4,268	3,545	83,706
No.of servers with UPS													
4-9	1,971	52	550	2,905	906	802	670	3,262	674	1,779	1,331	1,385	16,287
10-19	1,935	72	517	1,778	587	793	805	2,174	722	1,965	1,014	667	13,030
20-49	4,158	188	610	2,086	471	1,505	1,541	2,645	1,299	2,492	2,122	906	20,022
50-99	5,255	252	517	2,014	274	1,403	1,616	1,976	975	1,337	1,929	631	18,179
100-199	8,169	251	427	2,321	316	1,746	2,459	2,366	1,464	1,273	3,079	593	24,465
200-249	2,334	161	74	418	79	519	703	572	299	339	710	236	6,442
Total	23,822	975	2,695	11,522	2,632	6,768	7,795	12,995	5,432	9,184	10,185	4,417	98,424

3. Projected no. of companies with air-conditioning systems by sector and company size

Employees per workplace	MANU-FACTURING INDUSTRY	ENERGY & WATER SUPPLY	CON-STRUC-TION	TRADE; VEHICLE REPAIR & CONSUMER GOODS	CATERING	TRANSPORT AND COMMUNI-CATIONS	LENDING AND INSURANCE	PROVISION OF SERVICES TO TO COMPANIES	PUBLIC ADMINISTRA-TION; DEFENCE AND SOCIAL INSURANCE	EDUCA-TION	PUBLIC HEALTH & SOCIAL SECURITY	PROVISION OF OTHER PUBLIC & PRIVATE SERVICES	Total
	D	E	F	G	H	I	J	K	L	M	N	O	
Degree of installation													
4-9	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
10-19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
20-49	0.60	0.60	0.24	0.24	0.24	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
50-99	0.86	0.86	0.60	0.60	0.60	0.86	0.86	0.86	0.86	0.86	0.86	0.86	
100-199	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	
200-249	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	
No. of companies with a-c													
4-9	2,136	55	2,245	4,186	2,096	823	499	2,302	631	663	847	897	17,381
10-19	936	37	948	1,107	619	344	274	592	317	375	235	188	5,974
20-49	1,737	82	525	569	233	577	454	617	515	422	492	235	6,458
50-99	1,067	52	311	383	99	274	213	233	191	119	248	71	3,262
100-199	583	18	123	211	52	121	114	104	104	45	144	28	1,646
200-249	103	7	13	23	8	20	22	17	13	7	22	6	260
Total	6,563	251	4,165	6,479	3,107	2,160	1,575	3,865	1,771	1,631	1,987	1,426	34,981
No.of servers with a-c													
4-9	696	18	194	1,025	320	283	237	1,151	238	628	470	489	5,748
10-19	683	26	183	628	207	280	284	767	255	693	358	235	4,599
20-49	2,803	127	215	736	166	1,015	1,039	1,783	876	1,680	1,431	611	12,481
50-99	4,612	221	349	1,358	184	1,231	1,418	1,734	856	1,173	1,693	554	15,382
100-199	7,169	220	375	2,036	277	1,532	2,158	2,077	1,285	1,117	2,702	520	21,469
200-249	2,048	141	65	367	69	455	617	502	262	297	623	207	5,653
Total	18,010	753	1,380	6,150	1,224	4,796	5,753	8,014	3,771	5,589	7,276	2,616	65,333