*Bundesamt für Energie*
*Office fédéral de l'énergie*
*Ufficio federale dell'energia*
*Swiss Federal Office of Energy*

***Electricity* Programme**
**Pilot and demonstration plants**

# Switching of servers in small and medium-sized companies

## Market demand and pilot systems

Summary of the following studies/projects:

- Use of servers in small and medium-sized companies (IPSO, Dubendorf)
- Switching servers: pilot installation in small and medium-sized companies, stage I (R. Brüniger AG, Ottenbach)
- Switching servers: pilot installation in small and medium-sized companies, stage II (Encontrol GmbH)
- Switching servers in a government office, stages I and II (Dr. Rolf Schmitz and S. Spillmann, Swiss Federal Office of Energy, Berne)

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## Extract

Data processing servers are normally in operation round the clock, even though it is often the case that their functions are not required at all at night and during the weekend. A representative market survey has demonstrated that, in typical small and medium-sized companies in the German-speaking part of Switzerland, the option of automatic shutdown of servers during certain periods would be welcomed as long as fully developed and reliable systems are available for this purpose.

The technical and organisational feasibility of switching servers has been demonstrated using four pilot installations that are to be successively further developed:

- Switching in a small business using a modified clock
- Switching in a small business with the aid of an uninterruptible power supply device
- Switching in a large government office using networked switch boxes
- Switching in a large government office using an internal Linux server and networked switch boxes

The goal was the same in all projects, namely to cut the operating times of central network components (servers, printers, etc.) by storing switching times in a scheduler (e.g. timer, UPS device or computer). Special software components were developed so that users of the network could be informed about the planned switch-off times and thus request an extension of the operating time if necessary. It was also a prerequisite that users must be able to activate a server that has been switched off (e.g. for the weekend).

One was able to obtain the following results through the use of automatic switching systems:
- Improved reliability thanks to controlled daily shutdown
- Remote booting of systems = time savings for system administrators
- Full separation from power supply = increased IT security
  (protection against unauthorised access and physical influences) during almost 50% of the time
- Saving of more than 50% in the consumption of electricity by servers

The components used in the pilot systems are still in the prototype stage, and considerable investments would be required in order to make them available for commercial use. The goal here is that the functions described in this report are to be installed in servers by the manufacturers themselves. In the meantime, further pilot projects need to be carried out in order to obtain additional findings, and an assessment of the potentials of switching servers needs to be made.

## Zusammenfassung

EDV-Server sind rund um die Uhr in Betrieb. Und dies obwohl in der Nacht oder am Wochenende in vielen Fällen gar keine Nutzung der Server-Dienstleistungen erfolgt. Eine repräsentative Marktuntersuchung zeigte, dass in typischen Klein- und Mittelbetrieben (KMU-Betriebe) in der Deutschschweiz das automatische Ausschalten von Servern während bestimmten Zeiten begrüsst würde, falls entsprechende ausgereifte und zuverlässige Systeme dafür existieren.

Die technische und organisatorische Machbarkeit des Schaltens von Servern wurde in vier Pilotanlagen gezeigt, die sukzessive weiter entwickelt wurden:

- Schalten mit umgebauter Schaltuhr in einem KMU-Betrieb
- Schalten mit Hilfe der unterbruchsfreien Stromversorgungsanlage (USV-Anlage) in einem KMU-Betrieb
- Schalten mit vernetzten Schaltboxen in grösserem Betrieb der Bundesverwaltung
- Schalten mit eigenem Linux-Server und vernetzten Schaltboxen in grösserem Betrieb der Bundesverwaltung

Allen Projekten gemeinsam ist, dass mit in einem Zeitplaner gespeicherten Ein- und Ausschaltzeiten (in Schaltuhr, in USV-Anlage oder in einem Rechner) die Betriebszeiten von zentralen Netzwerkkomponenten (Server, Drucker usw.) verringert werden. Spezielle Software-Bausteine wurden entwickelt, damit die Benut-

zer am Netz über die vorgesehene Abschaltungen informiert werden und sie bei Bedarf eine Verlängerung der Einschaltzeit bewirken können. Auch müssen stillgelegte Server (z. B. am Wochenende) bei Bedarf durch die Benutzer wieder eingeschaltet werden können.

Mit diesem automatisierten Schalten konnten folgende Ergebnisse erzielt werden:

- Erhöhung der Zuverlässigkeit durch tägliches kontrolliertes „Herunterfahren“
- Booten der Systeme von Ferne: Zeitersparnis für System-Manager
- Vollständige Trennung vom Stromversorgungsnetz: Erhöhung der Informatik-Sicherheit (Zugriff von Drittpersonen, physikalische Einwirkungen) während beinahe 50 Prozent der Zeit
- Einsparung von über 50 Prozent des Stromverbrauches von Servern

Die in den Pilotsystemen eingesetzten Komponenten befinden sich noch im Prototypen-Stadium. Für eine Kommerzialisierung der Systeme müssten noch beträchtliche Mittel investiert werden. Das Ziel ist, dass die hier vorgestellten Funktionen von den Herstellern direkt in die Server eingebaut werden. In der Zwischenzeit sollten in weiteren Pilotprojekten zusätzliche Erfahrungen gewonnen werden. Weiter sollte eine Potentialabschätzung für das Schalten von Servern durchgeführt werden.

## Résumé: L’enclenchement et le déclenchement des serveurs

Les serveurs sont généralement en service en permanence. Et ce, bien que beaucoup d’entre eux ne fassent rien de productif la nuit et le week-end. Trois projets-pilotes bénéficiant du soutien de l’Office fédéral de l’énergie montrent que les serveurs peuvent être mis hors service la nuit et le week-end, par télécommande et sans limitations pour les utilisateurs. Cela permet d’accroître la fiabilité de l’informatique tout en réduisant les coûts du courant électrique: les économies d’énergie sont toujours de 50%, sans compter les économies supplémentaires réalisées au niveau de la climatisation. Contrairement aux hypothèses des constructeurs de serveurs de réseau, la coupure contrôlée des serveurs durant la nuit et la fin de semaine est – selon une étude de l’Office fédéral de l’énergie – un sujet à examiner. C’est ainsi que 57% des petites et moyennes entreprises interrogées seraien favorables à l’enclenchement et au déclenchement automatiques d’un serveur à une heure déterminée ou en fonction d’un événement donné. L’enclenchement et le déclenchement des serveurs, avec bien entendu l’arrêt contrôlé du système d’exploitation, ont été réalisés selon diverses approches. On a commencé par une minuterie transformée simulant une coupure de courant au serveur. Le projet-pilote le plus récent dispose de son propre ordinateur Linux planifiant l’utilisation des serveurs, surveillant les réactions des utilisateurs et commandant plusieurs boîtes de commutation par l’intermédiaire du réseau. Les systèmes-pilotes réalisés ont fait leurs preuves en pratique mais ne sont pas encore arrivés à maturité de série. L’objectif à long terme consiste à intégrer aux serveurs mêmes une fonction de veille prise automatiquement dès que le serveur n’est pas ou que peu actif, par exemple pour le maintien de la communication.

# 1 Introduction

Over the past few years, manufacturers of electronic equipment have been making major efforts to lower the stand-by[1] power consumption of their various products. For example, Advanced Power Management in Windows operating systems (Windows 98, Windows 20000) optimises the power consumption of computers. But little attention has been paid until now to the energy consumption of data processing servers, even though these account for 1.6% of Switzerland's electricity consumption. This concerns a total of around 800 GWh per annum, which is equivalent to the annual consumption of a Swiss city the size of Lausanne (150,000 inhabitants). This lack of activity with respect to networks is primarily attributable to the ever-increasing complexity of the systems in use, and to fears on the part of operators that manipulations carried out on their networks may give rise to malfunctions or cause them to become unstable. Another factor is that systems that are networked throughout the world need to have certain computers such as Web, mail or FTP servers at their disposal at all times. However, smaller networks or sub-networks linked to larger ones do not necessarily have to be fully accessible outside of working hours, and in fact for security reasons it may even be desirable that some servers remain entirely inaccessible at night and during the weekend.

The Federal Office of Energy approached this issue in two different ways:

1. It conducted an empirical market survey in order to find out whether the question of switching servers in small and medium-sized companies is an attractive proposition and represents an existing need.

2. It set out to demonstrate the feasibility of switching servers by initiating a variety of pilot projects involving different conditions of utilisation and operation in typical small and medium-sized companies. For these studies, the following minimum requirements had to be met:

   - Servers to be switched off outside of working hours if they were no longer being used
   - Independent monitoring of activities of attached clients, and start-up of required servers upon request
   - Communication with users:
     - All users to be notified before server is switched
     - Users must be able to request a postponement of shutdown of the server for a specified period
     - Users must be able to request that the server remains switched off for a given period.

# 2 Chronology of activities in the period from 1995 to 2000

1995 In a Novell network with 6 clients in use at the Engineering & Consulting Company R. Brüniger AG, a server, a CD device and a hub are switched off after working hours with the aid of a modified timer ([Bac 96]).

1995 At the Federal Office of Energy, a central server and printer are switched off outside of working hours using a control device. This system comprises control software implemented on a UNIX server, plus a control unit with 6 switching outputs.

1997 A study is carried out to calculate the savings attained by switching servers, and its finding is that power consumption is reduced by around 50%. (A brochure entitled "Energiesparen im Netzwerk – leicht gemacht" / "Energy efficiency in networks – made simple" provides a brief overview of the system ([Bfe 97]).

1997 Power consumption measurements are carried out on the components (routers, switches, multiplexers, micro-repeaters, media converters) of two modern networks with 82 and 1,200 users respectively ([Kun 97]). The findings are that the recorded levels are chronologically constant

[1] "Standby power" is defined by the International Energy Agency in Paris (IEA) as follows: Standby power use depends on the product being analysed. At a minimum, standby power includes power used while the product is performing no function. For many products, standby power is the lowest power used while performing at least one function.

and do not depend on the volume of data or the topology of the network. The readings obtained are around 30% lower than the specifications noted in the product descriptions, and this means that there is a risk of overdimensioning of infrastructure installations such as air-conditioners and uninterruptible power supply devices.

1998 The system undergoes further development at the Federal Office of Energy. Here, the control software is improved from a point of view of user operation, and is then installed on a specially designed internal Linux server.

1998 The solution installed at R. Brüniger AG in 1995 is also replaced by a new development: the servers are now switched using the intelligence and management software of a UPS device ([Hus 99]).

1999 Presentation of the new system at various workshops in Germany. Generally speaking, it meets with a great deal of interest, but the desire is expressed for a commercial version that is easy to install.

1999 Studies are carried out at the Federal Office of Agriculture concerning the implementation of the system, but its introduction has to be postponed due to modifications to the systems concerned. It also becomes apparent that operators of major and complex networks strongly resist the installation of new software elements on their servers. For this reason, it is decided to transfer the control software to a standalone computer equipped with a Linux operating system.

2000 Presentation of the pilot system to representatives from server manufacturers, with a recommendation to implement it. No response is received from the industry.

2000 An empirical market survey is carried out among 400 small and medium-sized companies in the German-speaking part of the country, who are questioned by telephone about their needs with respect to the option of switching servers ([Gub 00]).

2001 Presentation of the various projects at an international workshop entitled "Standby Power - Towards a Harmonised Solution" (www.iea.org/standby/index.htm) on 7 February in Tokyo by Roland Brüniger (cf. Appendix 1)

Future Vision: an efficient power-management system is directly installed on servers and network management tools.

# 3 Market survey

## 3.1 Objectives

By carrying out a statistical survey, the Federal Office of Energy set out to obtain representative findings regarding the effective demand for network servers at night, and at weekends and on public holidays, among small to medium-sized companies.

## 3.2 Procedure

In order to obtain the desired representative findings, a survey was carried out by **telephone** among 400 small and medium-sized companies in the German-speaking part of the country. The questions referred to installed servers and work stations equipped with PCs, to the utilisation of servers and the level of acceptance of the idea of switching them off at night and during weekends and public holidays.

The survey may be described as follows:

Sampling population: Small and medium-sized companies (10-200 employees) in the German-speaking part of Switzerland that are equipped with an IT network and at least one central server.

Sample: A random sample of 400 small and medium-sized companies was obtained by screening a random selection of such entities and identifying those equipped with a network server. The addresses of the companies comprising the random selection were obtained through

purchase. The survey was addressed to the persons responsible for IT (network or system administrators) at the companies selected.

Survey type: Telephone interview

Timeframe: Telephone interview: 24 July – 8 August 2000

Margin of error: When the results are extrapolated to the sampling population with a level of confidence of 95% in the group of target companies, a margin of error of max. ±4.9% applies

Utilisation rate: 72% of the target addresses that were actually interviewed

Applicability: The results may be regarded as representative and valid, given that a random sample was used and the utilisation rate was good.

## 3.3 Results

A detailed description of the results of the survey is to be found in a separate report entitled "Use of servers in small and medium-sized companies" ([Gub 00]), which is available on the Internet under "electricity-research.ch". Below is a summary of the most important results:

1. Approximately 80% of small and medium-sized companies in the German-speaking part of Switzerland use a data processing network today.

2. Approximately 80% of the servers in use are attached to an uninterruptible power supply device, and in approximately 50% of the companies participating in the survey, the room in which the server is located is air-conditioned.

3. Approximately 80% of servers in use operate under "Windows NT".

4. The majority of those companies that use a network leave their server on at night (94%) and during weekends and public holidays (90%), even though roughly 25% of them are not used at all at night and almost half are not used at all at weekends.

5. Around 2/3 of those servers that perform functions and processes at night require less than 3 hours for these operations.

6. 43% of those companies that use a server turn it off at least once a month (full separation from power supply).

7. An automatic system for switching servers on and off would be welcomed: 57% of the IT managers questioned were in favour of the idea that a server could be automatically switched on or off at a specified time or on a specified occasion, while 46% favoured the option of an automatic shutdown when the server is not required, coupled with the possibility of switching it on from a work-desk.

8. Those who were against automatic start-up and shutdown of a server seldom cited practical or technical reasons. Instead, they expressed uncertainties, an unwillingness to change existing practices, outdated notions or doubts regarding technical feasibility.

**Conclusions**: There is undoubtedly considerable scope for the introduction of automatic switching systems for network servers. However, the question whether this scope will be exploited depends to some extent on the availability of reliable technological solutions, but more significantly on the degree to which IT managers can be convinced about the technical feasibility, ecological desirability and economic benefits of such systems.

# 4 Pilot systems in the Swiss Federal administration

## 4.1 Stage I: using the intelligence of an existing central server

The Federal Office of Energy uses a sub-network that is part of the main one used throughout the federal administration. The installed servers run under UNIX and Windows NT. The sub-network with two servers, a number of shared printers and approximately 30 work-desks was used as the basis for a pilot study on the automatic shutdown of the central components. A control unit (switch box) with 6 switching outputs (230V, 8A) was installed in the middle of 1996. It was linked to the two servers, a central printer, a CD-ROM device and a variety of modems. The switching outputs were set up so that they could be controlled via Ethernet from a central server on the main network. A scheduling programme installed on this server was configured with on/off and control commands for automatic shutdown and start-up, and these could be adapted to the corresponding operating times. Each user was able to postpone shutdown by one-and-a-half hours (the postponement time could be programmed by the system administrator as desired). To postpone shutdown, all that was required was to press a specially designated key, which could also be used to restart the server. This process was triggered via the network by the central computer, which sent the corresponding command to the switch box.

The switch box (dimensions: 20 x 22 x 7 cm) was manufactured by EMCT in Schönbühl-Urtenen at a cost of around CHF 2,500.

Before this switching system was installed, the annual power consumption was 12,200 kWh, and during the trial this fell to 6,500 kWh. The resulting saving was 5,700 kWh, or approximately 47%.

## 4.2 Stage II: using the intelligence of a separate Linux server

### 4.2.1 System and network

This system (called "**AC Manager**" – where "AC" stands for alternating current) comprised a Linux computer and 2 decentralised controllers each equipped with 8 switching outputs.

The data processing network comprised the following users and components:

- Data processing work-desks 108
- Employees 95
- Network Ethernet 10 MB/s
- Servers 6 NT servers; LH Pro, supplied by HP
  5 UNIX servers; HP 9000 H40
- Tape stations 2
- Workstations 120
- Printers 11 laser printers; HP Laserjet 4M

The following devices were switched via the AC Manager:

- 4 NT servers (mail and home servers were left on permanently)
- 2 UNIX servers (database applications)
- 2 printers

The diagram below depicts the arrangement of the various devices and the network configuration:

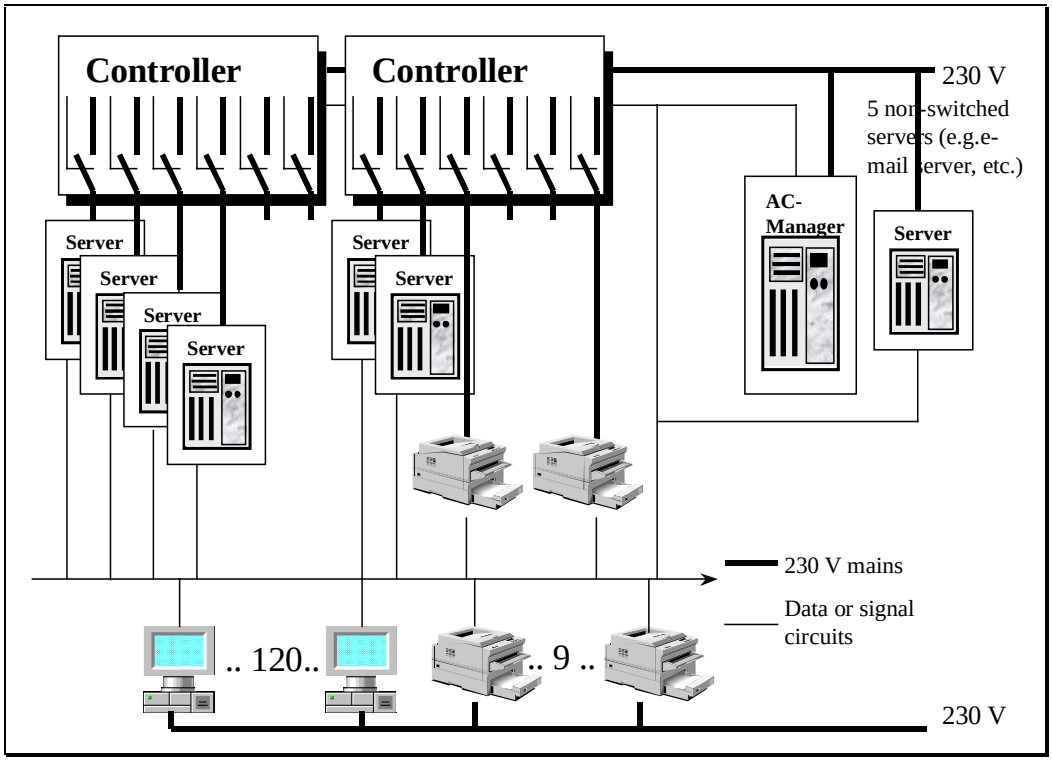



*Fig. 4.1: Overview of network configuration*

### 4.2.2 Control unit used in this project

The diagram below shows the electrical circuits of the control device:

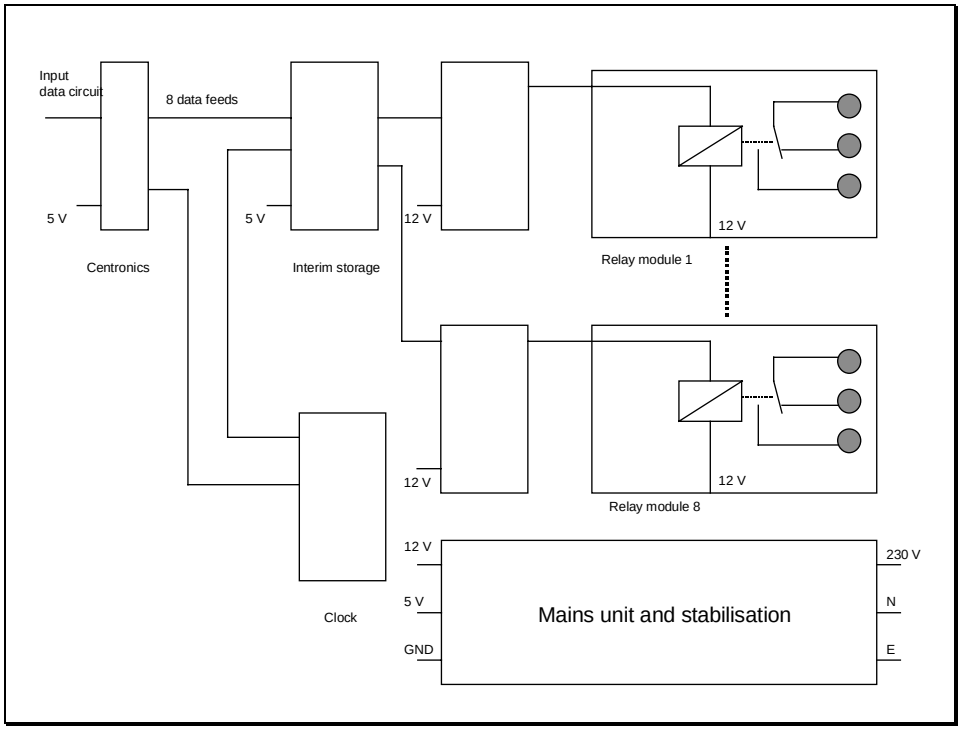



*Fig. 4.2: Circuit diagram of control unit*

The following components were used:

| Device | Components | Supplier |
|---|---|---|
| Linux computer | ASUS B2BS motherboard<br>128 MB RAM<br>4 GB Seagate hard disk<br>3COM 305B 10/100TX LAN card | Various manufacturers |
| Controller | 8 switching relays; Siemens BCC6;<br>12 VDC, 8 A/255 VAC<br>8 plugs<br>1 mains unit<br>1 relay control card: Auerswald | ECMT, Schönbühl |
| LAN interface | PSEU1P-4 print server | Micronet |

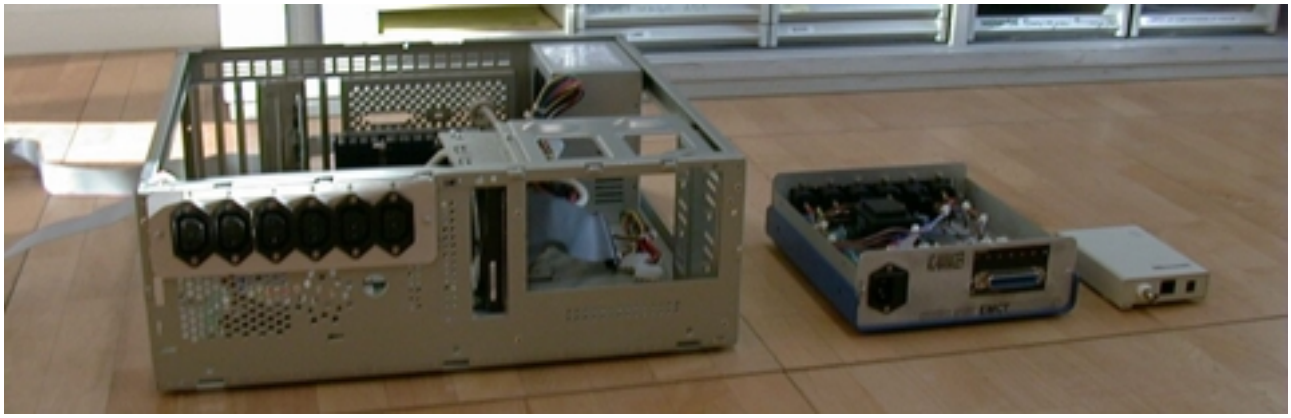


*Fig. 4.3: Linux computer with integrated control unit; separate controller with 8 switching outputs; LAN interface card (from left to right; view from front)*

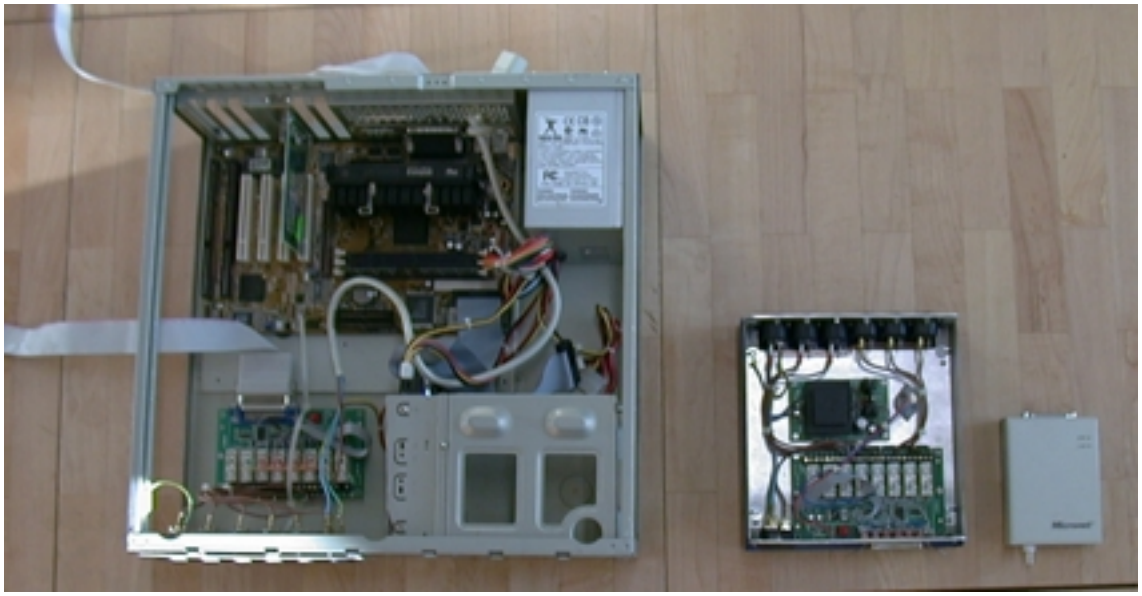


*Fig. 4.4: Linux computer with integrated control unit; separate controller with 8 switching outputs; LAN interface card (from left to right; viewed from top)*

### 4.2.3 Software

This device runs under the Linux operating system. A variety of programs are used for configuring and controlling the "AC Manager" switch box [Spil 00].

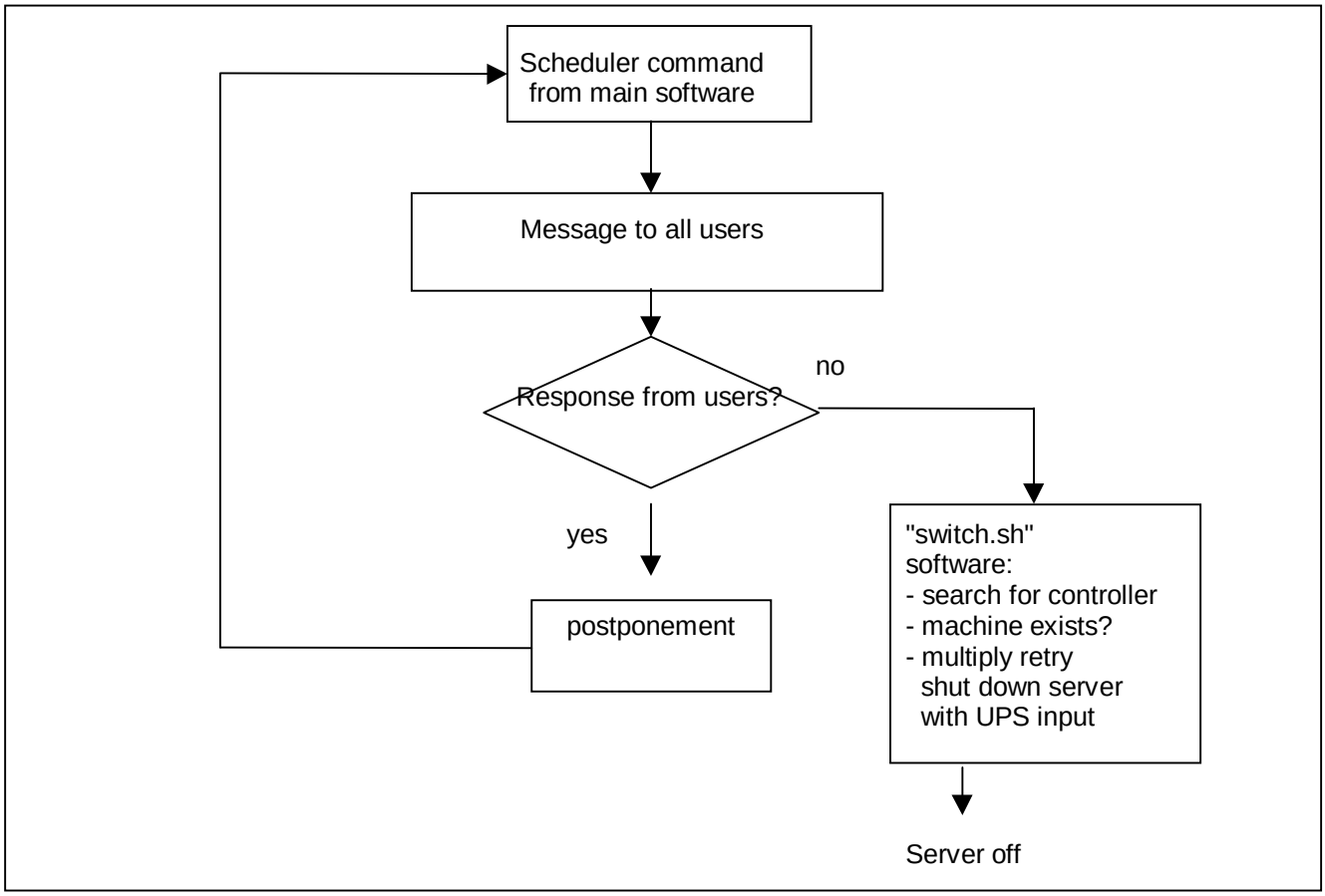



*Fig. 4.6: Flow chart for automatic shutdown of server*

### 4.2.4 User interface

Each user receives advance warning about an impending automatic shutdown of the server, on screen via the "Common Desktop Environment CDE“ and the "X11 software“ on the client, e.g.:

*Server will be shut down in 10 minutes!*

After a message concerning an impending shutdown appeared on screen, during the initial trial period any user wanting to continue working had to press a central key. In the second stage, it was possible for users to request postponement directly on screen.

### 4.2.5 Investments

- Development of software: approx. 80 man-days
- Development of hardware: approx. 20 man-days
- Hardware used in trial:

| | | |
|---|---|---|
| - computer: | CHF | 1,100 |
| - per Ethernet interface: | CHF | 300 |
| - per controller: | CHF | 500 |

If this AC Manager were to be manufactured in large quantities (series production), its unit cost would be around CHF 600 (Linux computer, including controller with 8 switching outputs), so a sales price of CHF 1,200 would be realistic. If additional decentralised switching outputs were required, the cost of a second control unit including LAN interface would be around CHF 500 (series production).

### 4.2.6 Power consumption

The measured power stand-by consumption of the devices in the configuration described in chapter 3 above is as follows:

- HP LH Pro server 150 W
- HP 9000 H 40 200 W
- HP 4M printer 25 W
- Linux computer 30 W
- AC Manager controller 2 W
- LAN interface of controller 2 W

The power consumption of the switched devices is 1,050 W, and that of non-switched devices is 1,125 W. The total capacity of the AC Manager is 38 W (Linux computer, 2 control units, 2 LAN interfaces to the control units).

The servers were switched off according to the following schedule:

| | |
|---|---|
| Monday to Friday | 9 p.m. to 6 a.m. |
| Saturday and Sunday | all day |

This means that they were shut down 93 hours a week, and in operation for 75 hours.

The printers were switched off according to the following schedule:

| | |
|---|---|
| Monday to Friday | 8 p.m. to 6.30 a.m. |
| Saturday and Sunday | all day |

This means that they were switched off for 100.5 hours a week, and in operation for 67.5 hours.

**Weekly power consumption of all components with AC Manager:**

| | |
|---|---|
| Server on (75 hrs x 1,000 W) | 75.0 kWh |
| Printer on (67.5 hrs x 50 W) | 3.4 kWh |
| AC Manager (168 hrs x 38 W) | 6.4 kWh |
| **Total** | **84.8 kWh** |

**Weekly power consumption of all components prior to shutdown:**

| | |
|---|---|
| Server (168 hrs x 1,000 W) | 168.0 kWh |
| Printer (168 hrs x 50 W) | 8.4 kWh |
| **Total** | **176.4 kWh** |

The annual power consumption for the servers was therefore 4,409 kWh. Without switching, the figure was 9,173 kWh (8,760 hrs x 1,050 W), so the resulting saving was 4,764 kWh p.a., or 51%. Given an average electricity tariff of 15 cents/kWh, this results in savings of CHF 714 p.a.

### 4.2.7 Practical findings

The system functions well. The administrator uses the AC Manager actively, for otherwise he would not be able to perform a remote restart of servers that have been completely shut down, which saves him a great deal of time and effort.

The following results were obtained using this automatic switching system:
- Increased reliability thanks to daily controlled shutdown
- Remote booting of systems = time savings for administrator
- Full separation from power supply = increased IT security
  (protection against unauthorised access and physical influences) almost 50% of the time
- Savings of more than 50% in power consumption of servers

At this time, the system has not been fully exploited, so there is practically no interaction with users (requests for postponement). There is another reason why almost no requests for postponement are made: mail and Internet services are currently provided via a non-switched server. And users are also able to process files in the normal way that have been downloaded by the server to a local workstation.

# 5 Pilot systems in a typical small to medium-sized company

## 5.1 Stage I: switching with a modified timer

In 1995, a system was installed in a Novell network with 6 clients that switches off a server outside of normal working hours with the aid of a modified timer. Operating systems on a server are equipped with standardised hardware and software interfaces that perform a controlled shutdown within a specified period after detecting a power failure. For this trial, a timer was modified to simulate a power failure at specified times via a relay contact, and thus the operating system was shut down in a controlled manner and subsequently separated from the power supply. Users were given the option of delaying this shutdown by three hours by operating a central key. This also meant that it was possible to start up the switched-off network (e.g. at weekends) at the press of a key. As a result, it was possible to cut the annual power consumption for this server from 814 to 284 kWh, or by 65%.

This project has been described in a report entitled "Efficient energy management in computers and communication networks: findings from a demonstration project and a Swiss pilot study" ([Bac 96]).

## 5.2 Stage II: switching using the intelligence of a UPS device[2]

In stage II, the servers were switched using the intelligence of a UPS device and corresponding management software (Federal Office of Energy: switching of servers: pilot system in a small to medium-sized company; publication no. 805.089.7d, Berne, November 1999 [Hus 99]). The commercially available management software provided by the supplier of the UPS device was modified using a simple Windows script program, and the system has been running to the full satisfaction of the company concerned.

### 5.2.1 Objectives

The aims of this trial were to gain practical experience and record the savings in electricity consumption.

The system called for the following functions:
- Scheduled, programmable shutdown of servers via a UPS device at night and during the weekend
- Automatic start-up of the servers upon expiry of the programmed down time
- Notification of all users prior to shutdown
- Postponement of shutdown by users via a client
- Manual start-up of the servers by a user of a client
- Manual shutdown of the servers by a user of a client

### 5.2.2 System and network

The diagram below depicts the arrangement of the various devices:

[2] UPS: uninterriptible power supply

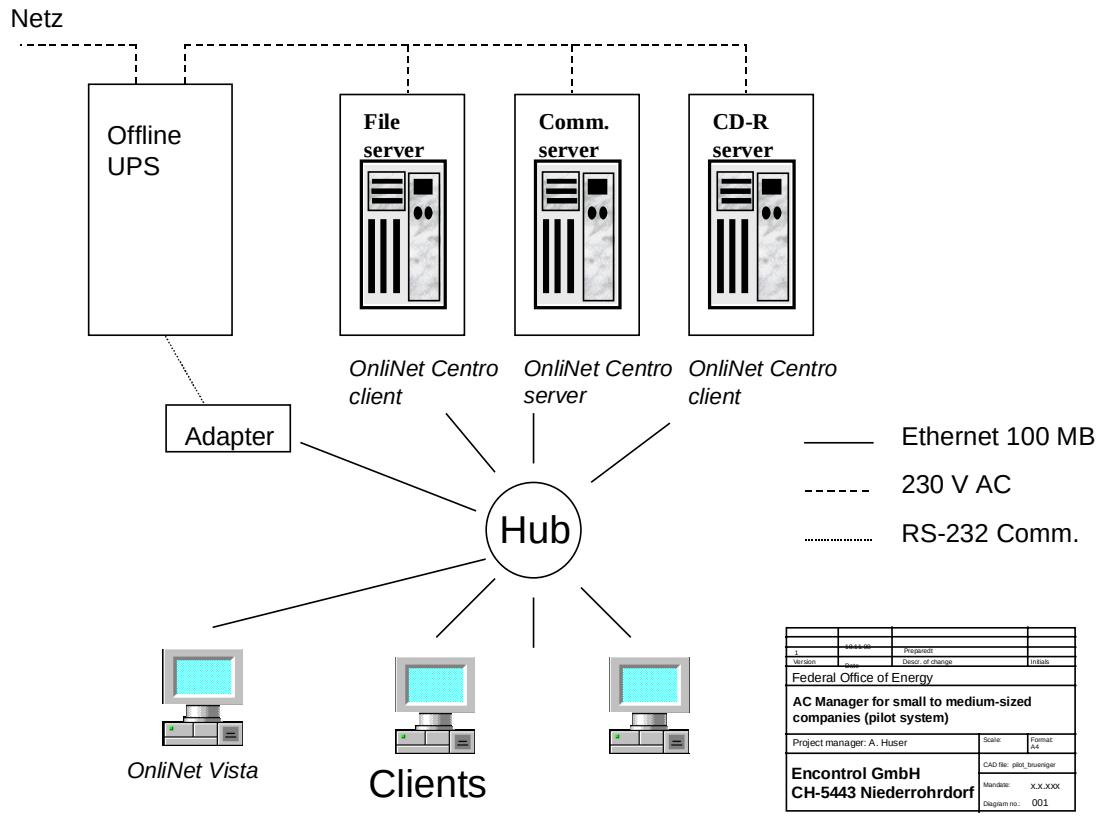



*Fig. 5.1: System and network*

**UPS device:**

| | |
|---|---|
| Manufacturer | Exide Electronics |
| Type | NetUPS Line Interactive |
| Capacity | 1900 VA, 1400 W |
| Mains adapter | ConnectUPS$^{TM}$ SL with connection for Ethernet 10baseT |

**Data processing devices on the UPS unit:**

| | |
|---|---|
| Server | Compaq Proliant 1600 (156 MB, 3 x 9 GB) |
| Backup server | Compaq Deskpro 4000 |
| CD-ROM server | Axis 4 x CD-ROM |
| Monitor | Compaq 17“ |
| Modem | Zyxel Omni 288s (x 2) |
| CPU switch | Maxxtro |

**Network and workstations:**

| | |
|---|---|
| Network | Ethernet 100 Mb/s |
| Workstations | 8 x Compaq |
| Printers | 3 x laser, 1 x colour inkjet |

### 5.2.3 Software

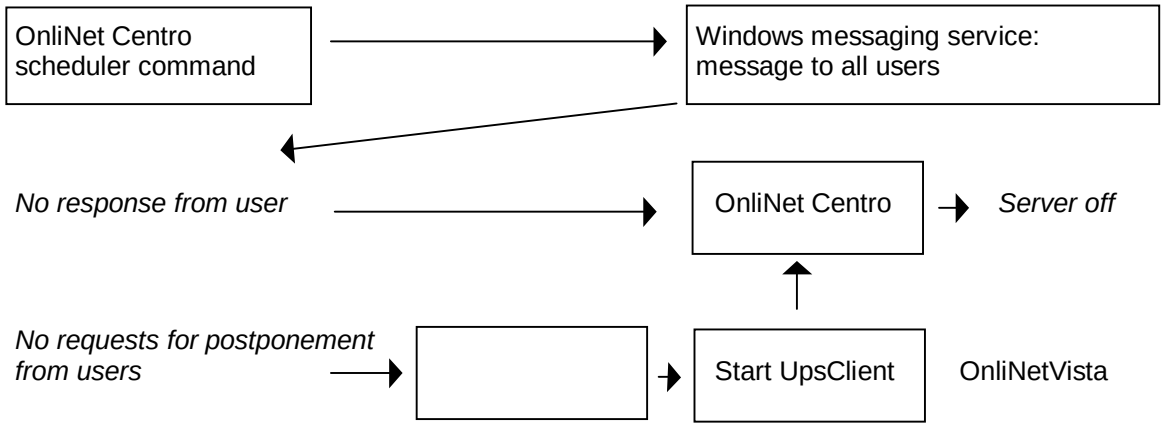
The USP device is controlled using the software provided by the manufacturer:

- Onlinet Centro[TM3] on the server
- Onlinet Vista[TM4] on the clients

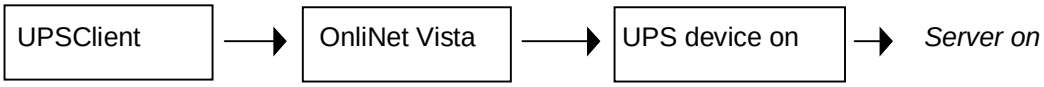
A simple user interface was programmed in order to provide users with communication and influence options. This interface controls the "Onlinet© Vista" software via Windows script commands.

The programs were used as follows:

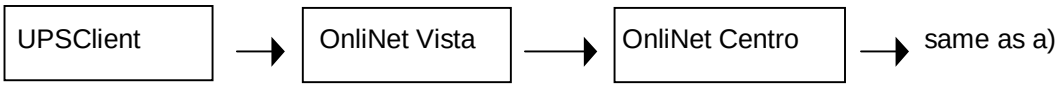
**a) Automatic shutdown of server:**




**b) Manual start-up of server outside normal operating hours:**




**c) Manual shutdown of server outside normal operating hours:**




Users receive a warning on screen prior to automatic shutdown of the server, e.g.:

*Server will be shut down shortly! If you wish to continue working, please start "UPSClient"!*

If a user receives a message concerning an impending shutdown of the server but wishes to continue working, he or she has to launch the "UpsClient" software and select "Prolong operating time". Options: prolong until 11 p.m. or 2 a.m.

[3] Registered trademark of Exide Electronics Corporation, Raleigh, NC, USA

[4] Registered trademark of Exide Electronics Corporation, Raleigh, NC, USA

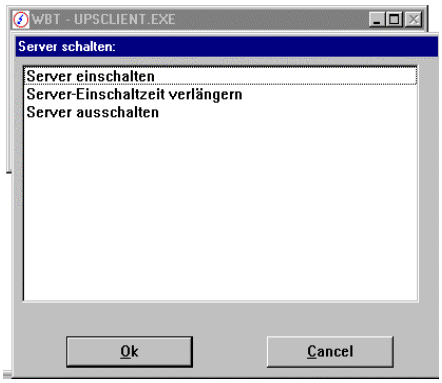



*Fig. 5.2: System and network*

If the UPS device and server are switched off, users can manually switch the latter on again by launching this program and selecting "Switch server on". In the same way, the server can be shut down again by selecting "Switch server off". The software then automatically calculates how much time is left until 6 a.m. the next day, and will automatically switch the system on again at this time.

After one of these functions has been selected, the program displays the following message:

*Operation successfully executed!*

### 5.2.4 Power consumption

The measured power consumption of the devices as configured in chapter 6 above is as follows:

| | | |
|---|---|---|
| Devices connected to UPS: | 256 W | 310 VA |
| UPS in stand-by mode, connected devices off | 25 W | 107 VA |
| UPS with all connected devices | 276 W | 345 VA |

The servers are automatically shut down according to the following schedule:

| | |
|---|---|
| Monday to Thursday | 8.15 p.m. to 6 a.m. |
| Saturday morning to Monday morning | 1 a.m. to 6 a.m. |

This means that the servers are switched off 92 hours a week, and in operation for 76 hours.

| | |
|---|---|
| Weekly power consumption when switched on | 20.1 kWh |
| Weekly power consumption during shutdown | 2.4 kWh |
| Total | 22.5 kWh |

This results in an annual power consumption of 1,170 kWh for the servers. Without shutdowns, the figure was 2,418 kWh (8,760 hrs x 276 W), so the resulting saving was 1,248 kWh p.a., or 52%.

### 5.2.5 Practical findings

The system installed in a Windows NT environment has been running to the full satisfaction of the company concerned, which reported the following benefits:

- Reduction of electricity consumption by 50%
- Protection against unauthorised access and electromagnetic interference outside of working hours
- Stable system thanks to optimisation of system shutdown and daily shutdown

The user reported the following weak points:

- The stand-by power consumption of the UPS device is too high at 25 W
- The performance factor in stand-by mode is very low (measured cos. $\varphi = 0.24$).

# 6 Recommendations

Within the industry, the topic of switching off servers is not being given consideration at this time. While solutions for remote management of clients in networks are available, and efficient energy management of workstation computers is already technically feasible, in the area of servers the mottoes "Never touch a running system" and "Always on" still apply today.

But for many server applications, controlled shutdown into off or low stand-by mode offers a number of benefits, and for this reason the experts in attendance at the international workshop on "Stand-by Power – Towards a Harmonised Solution" (www.iea.org/standby/index.htm) held in Tokyo on 7 February 2001 displayed a great deal of interest in the findings obtained from these pilot projects.

Both the hardware and the software currently being used in pilot systems are still in the prototype stage, and this means that **significant investments would be required in order to make these products commercially available**. In particular, the configuration of the systems concerned would need to be simplified and made more self-explanatory for users. In order to achieve a breakthrough with the solutions described above, it would be necessary for major international server manufacturers to bring them onto the market, and this means they need to be convinced about the benefits of switching servers. A first step in this direction would be to **publish the results of these pilot tests in international computer journals in English**.

A preliminary survey among server suppliers in Switzerland revealed that they do not have sufficient resources for developing the systems described here, even though they acknowledge the following benefits:

- Increased reliability as a result of daily controlled shutdown
- Remote booting of systems = time-savings for administrators
- Full separation from the power supply = enhanced IT security (protection against unauthorised access and physical influences) during almost 50% of the time

These benefits clearly emphasise the need to attract the interest of **major international companies** in these systems.

To motivate additional partners to implement commercially available solutions, it would be necessary to gather further **data regarding market potential**. As the next step, a study should be initiated to clarify this aspect, as well as to assess the **electricity savings potential** associated with these systems.

Initially, the goal will probably have to be limited to systems that switch servers into a lower stand-by mode rather than separating them from the power supply altogether. Here, the server would automatically assume this mode if it is no longer active or is only performing minor tasks such as maintaining communications. Until we reach this stage, we will be able to use new prototypes to bring us closer to the goal of efficient energy management in the area of information technology, combined with enhanced security and reliability.

# 7 Suppliers and partners involved in the projects described above

We would like to express our thanks to the following persons and companies for their active collaboration in these projects:

- Michael Gruber and Matthias Peters
  IPSO – a competence centre of IHA-GfM
  Zurichstrasse
  8600 Dubendorf

- Swiss Federal Office of Energy, Berne
  Dr. Rolf Schmitz; Stephan Spillmann, Systems Manager and developer of AC Manager

- Manufacturer of the hardware for the "Federal Administration" pilot system:
  Mr Müller
  ECMT
  Moostrasse 3
  3322 Schönbühl

- Operator of the pilot installation in a small to mid-sized company:
  R. Brüniger AG, Ottenbach
  Roland Brüniger; Dieter Schnurrenberger

- Supplier of UPS device and accompanying software ("Onlinet→ Centro; Onlinet→ Vista" for the small to mid-sized companies pilot installation:
  EHAG AG, Maur
  Th. Hediger

- Manufacturer of the hardware for the "Switching with a modified timer" pilot project:
  Linard AG
  9506 Lommis

# 8 Glossary

| | |
|---|---|
| Central devices | Devices that are shared by a number of users (e.g. servers, printers, etc.) |
| Data processing network | Collective term for data processing devices linked via a network (server, clients, workstations, monitors, printers, communication devices, etc.) |
| End devices | Work-desk equipment, e.g. workstations and PCs |
| Gateway | Coupling device that links data flow between different network areas |
| Hub | Amplifier with a number of inputs and outputs that enables star-shaped branching of network cables of all types |
| Network components | Devices that are essential for ensuring data flow in a data processing network (communications servers, gateways, hubs, routers, bridges, etc.) |
| Router | Coupling device that links a number of networks together and transmits data packages from a sender to a recipient by using various sub-networks. The sender only has to know the recipient's address, but not the route through the networks. |
| Server | Central computer that provides services such as data management, calculation, communication, etc. for other computers (i.e. clients) |
| Standby | “Standby power“ as defined by the International Energy Agency (IEA) in Paris. Standby mode differs according to device. At the least it is the power required by a device if it is not performing any functions. For some devices, standby power refers to the power that it requires when it is only performing one or a handful of basic functions |
| Switch | Coupling device that links data flow between network areas of the same type |
| UPS | Stands for uninterruptible power supply. Refers to a device that supplies connected equipment with power for a specified period in the event of a failure of the mains supply |

# 9 References

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[Bac 96] Bachmann Christian & Roland Brüniger: Effizientes Energiemanagement in Computer- und Kommunikationsnetzwerken: Ergebnisse eines Demonstrationsprojektes und einer schweizerischen Pilotstudie; im Auftrag des Bundesamtes für Energiewirtschaft, Bern, 1996 (*Efficient energy management in computers and communications networks. Findings from a Swiss demonstration project and a pilot study carried out on behalf of the Federal Office of Energy, Berne, 1996*)

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[Spil 00] Spillmann Stefan: Beschreibung Softwarekomponenten für das Schalten des AC-Managers, Bundesamt für Energie, Bern, 2000 (*Description of software components for switching the AC Manager. Federal Office of Energy, Berne, 2000*)

# 10 Appendices

Appendix 1: Project presentation by Roland Brüniger at the international workshop on "Standby Power - Towards a Harmonised Solution" (www.iea.org/standby/index.htm) held on 7 February 2001 in Tokyo

Appendix 2: Energy efficiency in computer networks

# Appendix 1: Overheads of presentation of R. Brüniger

## Switching off Servers over night/weekends in small and medium-sized companies

**Results of several Pilot projects and a Study funded by the Swiss Federal Office of Energy Research-Programme "Electricity"**

February 7/8, 2001, Tokyo

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Switching off Servers over night/weekends of small and medium-sized companies

## Titles of the Studies/Projects

- Pilot Installation in a small office
- Pilot Installation in the Swiss Federal Office of Energy
- Survey about switching off Servers in small and medium sized companies

February 7/8, 2001, Tokyo

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Switching off Servers over night/weekends of small and medium-sized companies

## Agenda

- Introduction of subject
- Experiences in a pilot project of a small company
- Experiences in a pilot project at the Swiss Federal Office of Energy
- Survey
- Conclusions
- Recommendations / next actions

February 7/8, 2001, Tokyo

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Switching off Servers over night/weekends of small and medium-sized companies

## Introduction of subject

- 1,6% of Swiss electricity consumption is used by computer / networks
- This is about 770 GWh per year
- Optimization potential by efficient devices is estimated by about 210 GWh (27%)
- Optimization potential by network energy management is estimated by about 220 GWh (28%)

February 7/8, 2001, Tokyo

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Switching off Servers over night/weekends of small and medium-sized companies

## Introduction of subject

- Servers are on 24h/day and 365 days/year
- Small and medium companies do not need Servers over night (statement!!)
- Energy saving potential is relevant
- Nobody dares to touch a running Server
- IT-people are reluctant to switch Servers
- IT-Industry has no solution for that

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Switching off Servers over night/weekends of small and medium-sized companies

## Pilot project 1

- First pilot project was started 1995 and proved that switching Servers off is possible (installation was live until 1998)
  - 6 PCs, 3 Printer networked
  - 1 Novell-Server, Tape, Modem
  - Energy manager using the UPS alarm at the server to simulate system down
  - Interaction only via Energy manager

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Switching off Servers over night/weekends of small and medium-sized companies

# Pilot project 1

**Energy reduction of 50 % of the central components was achieved**

Energy Manager

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# Pilot project 1

**Installation of Energy manager (EM) with server**

**Power Consumption without EM: 814 kWh/a**
**Power Consumption with EM: 284 kWh/a**
**Energy savings (65%): 530 kWh/a**

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# Pilot project 1 - Update

- **Follow up project was launched on a Software base (1999 until now)**
- **UPS installation was also considered and is central point of intelligence**
- **Change to MS NT-Server-Network**
- **Standard running time is defined**
- **Interaction (switching, prolongation etc.) is purely via the PC**

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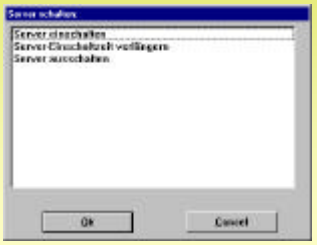
# Pilot project 1 - Update

**GUI on PC (human Interface)**

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# Pilot project 1 - Update

**Major results:**

- **It is stable working in a productive area**
- **E-Mail is stored at the provider (WEB-hosting would not be possible)**
- **It is accepted by the people and does not bother the daily business**
- **Commercial product not yet made**
- **UPS needs 25 W for Standby!!**

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# Pilot project 2

**AC-Manager at the SFOE (since 1996)**

- **29 Workstations, several printers**
- **Mixture of UNIX- and NT-Servers**
- **AC-Manager includes AC-Breaker with 6 outlets, control-SW on running Server**
- **AC-Manager can be controlled via Network or via modem (system manager)**
- **Interaction of user only via central box**

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# Pilot project 2

## AC-Manager at the SFOE (since 1996)

Power Consumption without ACM: 12'191 kWh/a
Power Consumption with ACM: 6'503 kWh/a
Energy savings (47%): 5'688 kWh/a

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# Pilot project 2 - Update

## AC-Manager at the SFOE (since 1998)

- 120 Workstations, several printers
- 2 UNIX, 4 NT-Servers, 2 printer switched
- AC-Manager-Software integrated in a Blackbox (Linux-Server, always up)
- AC-Manager can be controlled via Network or via modem
- Interaction of users via workstation

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# Pilot project 2 - Update

## AC-Manager at the SFOE (since 1998)

AC-Manager with 6 outlets and additional controller

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# Survey-study (year 2000)

## Is switching off Server requested?

- Representative statistical telephone survey with 400 small and medium-sized companies
- The main questions were:
  - Do you have a network in your company
  - How long does your server(s) work over night/weekend
  - What is the operating system of your server(s)
  - Do you switch off your server(s) over night / weekends
  - Would you like an automatic shutoff of your server(s) with the possibility to switch them on manually if needed

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# Survey-study (year 2000)

## Results (Small and medium-sized companies = SMC)

- 80% of the SMC have a network
- 80% of the servers are connected to an UPS
- 50% are placed in an air conditioned room
- 80% of the servers have NT as OS

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# Survey-study (year 2000)

## Results (Small and medium-sized companies = SMC)

- 94% of servers are on over night
- 90% of servers are on over weekends
- 2/3 of servers working over night need less than 3 hours for that work
- 43% of SMC do shut down their servers once a month

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Switching off Servers over night/weekends of small and medium-sized companies

## Survey-study (year 2000)

**Results** (Small and medium-sized companies = SMC)

- 57% of the SMC are positive to switch servers automatically
- Reasons for being against this idea are mostly doubts, uncertainty, reluctance for new ideas etc. and NOT explainable facts

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## Summary / Conclusion

- Several pilot projects proved the concept of switching off Servers in SMC
- Analysis for proper implementation needed
- Achieved Energy savings are substantial
- Customers are positive for this idea
- A commercial available solution is needed
- Industry (at least the contacted industry) is still reluctant to implement it

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## Advantages of switching off

- Remote Booting (Hard-Booting) possibility gives new features (e.g. in large company areas)
- Daily shutdown increases server-stability
- Prevents hacker attacks during off time
- Reduces electricity costs of servers of about 50%

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## Recommendations/Actions

- Study to precise the estimated electricity saving potential (CH, EU)
- Push industry to implement the switch off functionality into servers
- Promotion of these innovative solutions
- Cooperation on international level
- UPS efficiency in standby must be improved

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## Documents (in English)

- The Energy efficiency of computer networks
- Efficient Energy management in Computer and Communication Networks
- Energy efficiency in networks - made simple

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## Further information

**www.electricity-research.ch**

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# Appendix 2: THE ENERGY EFFICIENCY OF COMPUTER NETWORKS

**1.6% of Switzerland's electrical energy is used by networks. This amounts to about 772 GWh annually equivalent to the electricity consumption of a Swiss town the size of Lausanne with its 150,000 inhabitants. An appropriate choice of equipment and specific measures for energy optimization could reduce this consumption by more than 50%. Energy-optimized devices in computer networks could result in a saving of more than 210 GWh of electrical energy per year. A further savings potential of more than 220 GWh lies in the use of a network energy management system. This is shown by a recent study of the Swiss Federal Office of Energy.**

The study investigates the energy consumption and the possibilities for power savings of computer networks in Switzerland. In addition to the analysis of existing statistical material, the study is primarily founded on a series of expert discussions with network specialists and users. It was conducted by the company Meyer & Schaltegger AG at the request of the Swiss Federal Office of Energy.

More and more working places are being integrated into computer networks nowadays, for more and more information has become available in electronic form. Computer networks consist of distributed systems of computers and peripheral equipment interconnected by data lines, thus allowing the sharing of informations and resources. Already today, two thirds of Swiss establishments with 20 or more employees use networks today.

All devices connected to networks are included in the energy calculations. These are mainframe computers and special network components as well as personal computers, monitors and printers. The mainframe computers consume approximately two thirds of the energy, about one fourth of the consumption goes to working-place devices, the rest can be attributed to network components.

We have also assessed the potential savings made possible by consistent use of the energy-optimized devices available today; this could reduce the energy consumption by 212 GWh or 27%. These savings would be achieved if in future acquisitions energy-optimized devices are chosen.

In addition, we investigated the effects of a network energy management system, that is, a selective shutdown of devices outside their normal utilization periods. The use of such an energy management system for all networks would further reduce the energy consumption by 222 GWh or 29%. In order to be effective, such an energy management system must be able to function automatically.

Various factors influece the achievable savings. Relevant criteria include the size of the enterprise and network and the network type. Medium-sized and large establishments with their numerous connected working places have the greatest savings potential. Mostly, these are networks into which larger computer systems, minicomputer and mainframe computers have been integrated. Even though 25,000 networks are installed in small businesses, their share in energy consumption accounts for merely 43 GWh or hardly 6%.

Another factor is the operating time of the network. One may assume that most networks operate only during the office hours. This is the case mainly with small and medium-sized businesses, while larger establishments use worldwide networks that remain in operation around the clock.

In the future is to be expected a further increase in the number of networks. New worldwide communication facilities may dramatically increase the number of installations, even with small businesses. The use of all available options to optimise energy consumption thus appears to be of utmost importance.