Intermediate step report for EuP study Lot 3

Task 3

Consumer behaviour and local infrastructure

Contractor

IVF Industrial Research and Development Corporation

Anna Karin Jönbrink and Rafael Amen

Argongatan 30

SE 431 53 Mölndal

Sweden

Phone: +46 31 706 60 00

E-mail: anna-karin.jonbrink@ivf.se

www.ecocomputer.org

Preface

This report refers to directive 2005/32/EC of the European parliament and of the council of 6 July 2005 with the main objective to establish a framework for the setting of eco-design requirements for energy-using products.

To get a better knowledge about energy using products, and their environmental performance, and to prepare the coming implementing measures, there was a call for tender from the commission for preparatory studies in September 2005. These studies cover different product groups. The objective of the studies is to find out whether and which eco-design requirements could improve the environmental performance throughout the life cycle of the products relevant to that study.

This is the third draft report within the EuP preparatory study, Lot 3, Personal Computers (desktops and laptops) and Computer Monitors. The objective of this part of the study and the report is to describe the consumer behaviour and local infrastructure that will be used in subsequent parts of the study. The methodology developed by VHK for the European Commission (MEEUP 2005) is followed. A large corpus of information has been collected. The most important parts of it are described in this report. Since the project is ongoing, and some important background information may change, this part of the study may also be subject to changes. Please feel free to comment on this report to e-mail address: ecocomputer@ivf.se

For more information about the study, please refer to www.ecocomputer.org

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Summary

The general picture of computer usage pattern is an elusive one, in spite of the fact that several studies are available. “Computer usage pattern” is used in the meaning of how much time a computer is in the different modes: active,, idle, sleep and off. For this study, it is important to understand the usage patterns for office usage and for home usage. The usage patterns are very much influenced by the software and by Internet.

It can roughly be said that computers are in active use less than one third of the time. Regarding lower active modes, their respective usage times differ for central units and displays, but for several reasons the equipment goes into those modes much less often than could be expected.

Maintenance and repair of personal computers are often done under some kind of service agreement. The users make software repairs and changes more often than hardware changes or repairs. Regarding “End of Life behaviour”, it is very much influenced by the WEEE-directive, forcing all/most personal computers and monitors into an End of Life treatment, for which the cost was included in the original purchase.

1 Real life efficiency

Real life efficiency according to the VHK methodology includes many different issues. For personal computers and monitors the main issue is the frequency of use and type of use, which we hereby call the usage pattern.

1.1 Background

Back in 1977, DEC co-founder Ken Olsen said: "There is no reason for any individual to have a computer in his home" [Wikipedia]. Considering computer specifications by that time, he was obviously right. By 2006 the opposite seems more plausible, which shows what changes computers have undergone during the elapsed time. Their volume, weight and energy consumption have decreased by several orders of magnitude, whereas their capacity has made such quantitative increases that several qualitative changes in their usage have been made possible or even mandatory. Nothing indicates that this change rate will be slowing down anytime soon.

Currently, personal computers and monitors are used in so many different ways, that no clear-cut definition of their usage is possible. This is not a limitation of the analysis, but rather an intrinsic property of the devices: their capability and application area are intently open-ended. The use of specialised, single purpose computers for embedded systems is increasing rapidly, but it does not mean that personal computers are getting any less general-purpose. Even “home entertainment" computers keep all their generality and in no way become as specialised as TV or HiFi sets are.

Personal computers are becoming more and more communication machines: email has substituted mail to a major extent, and VoIP (voice over Internet protocol) and TV over Internet are becoming as popular as broadband. When computers are connected to broadband, there is a benefit from not switching them off, because of frequent automatic software updates, and in order to be reachable by a chat or VoIP. This makes people switch off the computers more and more seldom [Magnus Bergqvist, 2006].

Still, the communicating device is a further development of a calculating machine. A telephone or a mailbox consumes no energy while in stand by status; current personal computers do. This situation was acceptable when computers were used for limited time periods and then switched off, but using them as communication machines poses demands on access, response time and energy consumption that current personal computers do not fulfil.

This study also shows that there is a big lack of information on the issue. There doesn't seem to be available any extensive and recent survey on computer usage pattern. Studies are perishable, since the usage pattern has changed very much due to rapid performance and functionality changes in the computers. In past studies, much more effort seems to have been put into ascertaining and calculating power requirements and possible energy consumption reduction, than into ascertaining usage patterns, and by that means understanding the origin of the power and energy consumption figures.

Nevertheless, enough information has been put together both to give a rough image of the usage pattern and to indicate clearly that, even if the truth is beyond reach and some assumptions are unavoidable, a much more detailed picture can be expected of a deeper study.

1.2 System's influence on usage pattern

Some features induce and even compel more or less sustainable user behaviours. Features can be related to hardware or software, to producer or vendor, or a combination of several of them. For example

- A computer that takes a very long time (at the user's perception) to boot, or wake up from hibernation, will be switched off as seldom as possible.
- Unstable wake up from hibernation will drastically limit the usage of this feature.
- If system updates have to be run other than office-time, the system managers will enforce an "Always on"-policy.

- Broadband connections facilitate computer applications that tend to make the users to have the computer always turned on.

- If the computer is clearly “off”, normal users will not check if it still is consuming energy.

Users in general, and home users in particular, are very conscious of the computer’s initial cost, and to a certain extent of the costs for coming software and hardware upgrades. On the other hand they are seldom aware of the total cost for ownership.

Firms may budget for system administration and help desks, but the power management built into the computers is rarely a purchasing argument.

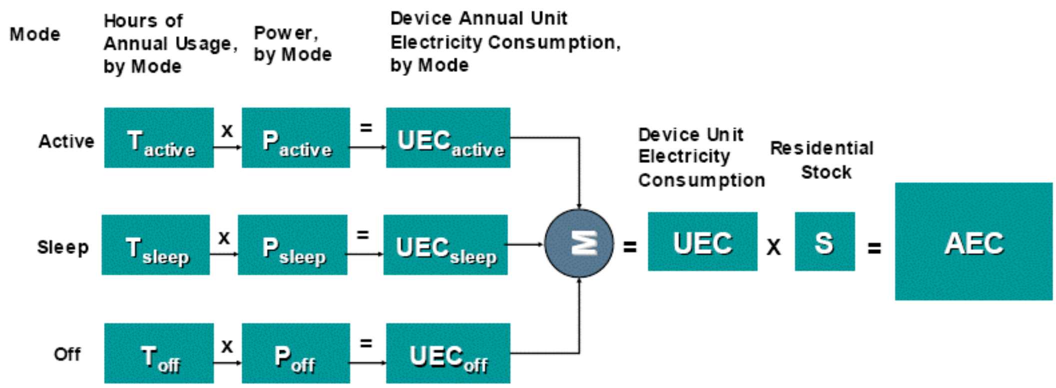
In other words: the users mostly behave rationally to achieve their perceived needs from the computer, but this behaviour need not be optimal from a sustainability viewpoint. If sustainability is to be achieved, an optimal usage pattern should be automatically enforced by the equipment. A non-sustainable system configuration will automatically lead to a non-sustainable usage pattern.

1.3 Information from reports and other sources studied

The procedure within this part of the study was to gather as much information as possible regarding usage pattern. The decision was to normalise it to common units, and make a general average of it. The information and how the normalisation was done are described below. In table 4 mean values from all sources are presented as the usage pattern that will be used in the subsequent tasks of this study.

1.3.1 **U. S. Residential Information Technology Energy Consumption in 2005 and 2010,** *prepared by TIAX LLC for U.S. Department of Energy [TIAX LLC, 2006]*

The report is mainly oriented towards developing a preliminary estimate of national annual energy consumption (AEC) for the USA, at present and in three possible scenarios. Their methodology is according to the following figure.



However, TIAX states: ” […] device usage patterns have the greatest uncertainty of any component of the AEC calculations” [p. 22]. The figures used in their calculations are based on telephone surveys. No home usage pattern is reported.

- In the USA, stationary PCs stand for 47% of the residential ICT electric consumption, laptops for 6%, and monitors for 18%. The ICT energy consumption is a small but increasing part of the total energy consumption: ~3% of the residential electricity consumption, ~1% of the national electricity consumption.

- Besides, the current estimations for ICT electric consumption have to be raised, mainly because PCs and monitors spend more time in active mode.

- Time is distributed as 83% active mode, 7% sleep mode, and 10% soft off; hard off is negligible.

- Reasons named not to turn off are: “Convenience – Will or may use again”, “Forget to turn it off”, “Can damage the PC”, “Too lazy”, “No reason to turn it off”.

- Access to broadband increases active mode time by approximately 25%

1.3.2 Fraunhofer report on possibilities of compulsory labelling

In the German report [Schlomann, 2005], several estimates have been presented on usage patterns, both for home use and office use of desktops, laptops and monitors. Estimates are made for 2001, 2004 and 2015, and are valid for Germany. The estimates are based on literature studies and experience. The data for 2004 are presented in table 1

Table 1, Estimated usage patterns, Germany 2004, [Schlomann, 2005]

Hours 2004	Normal operation	Standby	Off-mode	Off

PC-home	425	1417	4834	2084
PC-office	1540	660	5248	1312
Notebook-home	425	667	5251	2417
Notebook-office	1430	770	3280	3280
CRT-home	425	709	3813	3813
CRT-office	1540	880	5072	1268
LCD-home	425	992	3672	3672
LCD-office	1540	880	5072	1268

To make comparisons possible, the values for “Normal operation” and “Standby” are put together as “Active”. For “Monitor”, CRT and LCD are averaged.

1.3.3 Energy Star energy calculator, a tool presented by Energy Star

The tool suggests some standard usage patterns. [http://www.eu-energystar.org/]

- Home: Estimated average EU use 2003 (mainly web, e-mail). Derived from 'on-mode' 1.6 h/day in 2000 and 2.3h/day in 2010.

- Average office: Based on use for e-mail and occasional search/document/presentation: 3 hours per day active 'on' use, 1 hour 'on' preparing for standby. On 'standby' in other office hours (e.g. managers, sales representatives). Switched 'off' (using the PC power button, not disconnected from mains) at night. Power Users (video-editing, CAD) will probably better fit in the 'average office' profile.

- For both home and office usage, the model assumes 2 hours per day in On-mode, 9 h/d in Stand by-mode, and 13 h/d in Off-mode. [http://www.eu-energystar.org/en/index.html]

1.3.4 **Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings,** prepared by TIAX LLC for U.S. Department of Energy [TIAX LLC, 2004]

Case	Usage by Mode[27] [hours/week]		
	On	Sleep	Off
Baseline	98	7	62
Power Aware	98	7	62
Power Aware + 100% PM-enabled	19	86	62

As other reports show (see below), the condition "Power aware + 100% power management-enabled" is very seldom applicable. Thus, it is disregarded. The values from the other two lines (in fact, the same) are used for the groups Desktop Office, Laptop Office, Monitor Office and Desktop + Monitor Office.

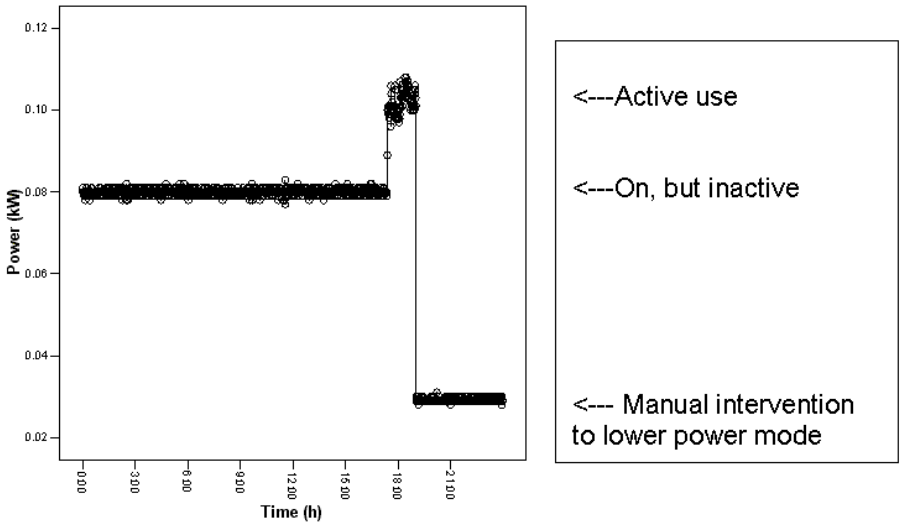
1.3.5 Monitoring Home Computers, by AEA

In March 2006, AEA Technology made a study called "Monitoring Home Computers" for the Market Transformation Programme (MTP) and the Energy Savings Trust (EST) in Great Britain. [AEA, 2006]

Method

The AEA method is different from the other studies, in that they have recorded home computers' power consumption every minute during two weeks. Power consumption shows a number of distinct thresholds, which can be associated to different usage modes, as follows

Figure 3 Data record for one computer - identifying a Low mode



[AEA, 2006, p. 13]

The measurements have been made in eighty households from ten different regions in England. In addition to the measurements, more information about the households and the computers was collected by means of questionnaires.

Results

The study came to the following conclusions

- Even where power management features are available on the computers, many computer users are not taking advantage of them.

- "Monitor off" was available on 95% of the computers where this feature was checked for availability. The most common setting (52% of the computers) was for the monitor to turn off after 20 minutes, and the average was 27 minutes. However, almost 27% of the computers with the feature had it set to "never".

- "Disks off" was most commonly set to "Never" (78% of the computers). When activated at all, the average delay time was 40 minutes.

- "Standby" was most commonly set to "Never" (78% of the computers). When activated at all, the average delay time was 23 minutes.

- "System hibernate" was most commonly set to "Never" (97% of the computers). The only computer that had it enabled had a delay time of 45 minutes.

- Most users were unaware what different energy marking labels (e.g. Energy Star, TCO, Nordic Swan, Blue Angel, Ecolabel) stand for.

Table 2. Usage pattern from AEA's report (Table 20), home use

Mode	Usage time h/day]	Usage time [h/year]
Mains Off	2,7	985,5
PC Off	15	5475
Low	0,2	73
Active	6,1	2226,5
Total	24	8760

These values can be regarded as the best available figures. However, their limitations are that

- they are valid only for home usage
- they do not discriminate between desktop and laptop computers.

1.3.6 EEDAL'06 (International Energy Efficiency in Domestic Appliances & Lighting Conference '06 [Presentation by Kurt Roth, 2006]

A presentation based on US studies

A rather coarse usage pattern is presented. It is not quantifiable in this report's terms.

Table 6. PC on-time data from RECS and calculated average on-time

	% of Households		Weekly hours on/week	
hours/week assumed to be the midpoint of the range	All	With a PC	Each PC	Share of Average
Households with PC *On*				
less than 2 hours/week	9.7%	17.3%	1	0.2
2 to 15 hours/week	24.6%	43.8%	8	3.5
16 to 40 hours/week	11.4%	20.3%	25	5.1
41 to 167 hours/week	5.3%	9.4%	80	7.5
all the time	5.2%	9.3%	168	15.5
Totals: %, share	56.2%	100%		31.8
Hours/week over 40				
41 to 167 hours/week		9.4%	40	3.8
all the time		9.3%	128	11.8

Sources: Nordman and Meier (2004) and EIA (2001)

[Kurt Roth, 2006]

1.3.7 EEDAL'06, (International Energy Efficiency in Domestic Appliances & Lighting Conference '06 [Karine Thollier, Institut de Conseil et d'études en Développement Durable, Belgium, 2006]

A presentation based on a study for the Belgium authorities.

No quantifiable information regarding usage pattern. Other interesting viewpoints:

- The resource consumption, including both materials during production and energy during usage, can be reduced by moving from CRT-displays to flat ones.
- The number of people enabling display sleep is grossly double as large as those enabling CPU sleep.
- "Hard Off" is negligible as compared to "Soft Off"

[Karine Thollier, 2006]

1.3.8 Förbättrad energistatistik för lokaler (Improved Energy Statistics for Buildings)

An inventory of 123 office and official buildings in Sweden.

No quantifiable information regarding usage pattern.

- PCs stand for 14,2% of the energy consumption in office buildings, and 15% when electric heating is excluded.

[Statens energimyndighet, 2005] (The Swedish Energy Authority)

1.3.9 Vart tar watten vägen? (Where does the Watt go?)

This is a Swedish report dealing with energy consumption in University buildings. It includes qualitative but no quantifiable information regarding computer usage pattern.

- Student PCs are left “On” for no apparent reason, whereas they could hibernate during grossly 50% of the time.

[Institutionen för Värme- och Kraftteknik, 2003] (Institution for Heat and Energy Technology, Lund’s University of Technology, Sweden)

1.3.10 Sustainable Products 2006: Policy Analysis and Projections, UK 2006

No quantifiable information regarding usage pattern. Other interesting viewpoints:

- “Non-domestic electricity use by ICT equipment has increased by nearly 70% between 2000 and 2005; domestic figures have more than doubled in the same timeframe.”

[www.mtprog.com , 2006]

1.3.11 Residential computer usage patterns, reuse and life cycle energy consumption in Japan

The report in based on a large survey, 1033 Japanese Internet users, and deals only with home computers. It concludes that they are in

- active mode 2,35 hours per workday and 2,8 hours per nonworking day on average
- sleeping mode 25% of non active time
- off 75% of non active time

Besides, it draws the following conclusions

- The question of what power mode the computer is in when not being used is key to reasonable estimation of electricity use.

- The survey informs that 78% of users are reporting that computers are turned off when not in use, 3,4% always on, 7,1% always on except at night, 8,5% in standby mode and 2,7% in hibernate mode.

[Eric Williams, 2005]

1.3.12 EPIC-ICT: Development of Environmental Performance Indicators for ICT Products on the example of Personal Computers: "Data needs and data collection, Generic Modules, Environmental impacts, Impact assessment and weighting, Environmental interpretation and evaluation" *[2005]*

One single computer (Dell OptiPlex desktop computer GX280) is used as model to Life Cycle Analysis of personal computers. Two usage pattern models are used

- EPA's (EnergyStar, i.e. 4 hours/day at maximum level, 5.5 h/d at minimum level and 14.5 h/d at off level)

- Dell's own, which is intended for newer products.

Already at this level there are major differences; when recalculating both patterns to hours per year and assuming off mode during weekends in the EPA model, they compare as follows

Table 3, Usage patterns in EPIC

Usage in [h/y]	Model	
Service level	EPA	Dell
Maximum	1040	250
Minimum	910	2943
Sleep	520	3223
Off	6266	2344

[EPIC, 2006]

1.3.13 TECHNOLOGIES DE L'INFORMATION ET ECLAIRAGE - Campagne de mesures dans 49 ensembles de bureaux de la Région PACA

This report deals with energy consumption reduction in offices. Even if it does not define any complete usage pattern, it does point out their main characteristics. Information used thereof

- Active time for stationary office computers: 3 h/workday
- Monitor sleep time: 68%
- Monitor active time: 25%

[ENERTECH, 2005]

1.4 IVF Survey 2006

IVF has sent a questionnaire to a number of companies and institutes, regarding the whole of Lot 3. In this report, the answers from sixteen respondents including market leading companies and a number of institutes are taken into consideration.

1.4.1 Power management

More or less advanced power management functionality is built into practically every new computer, but it is often partially disabled at the installation. “Display off” is more often enabled than “Hard disks off”, “Sleep” or “Hibernate”. The reasons may vary, but are probably mostly due to the capability of the operating systems.

- For office use, one reason can be system updates done overnight. Thus, for them to be effective, the computers must be “on” all the time, because waking them up from a central server is not a usual feature.
- For home use, the “wake up-time” can be experienced as bothersome, when computer usage is interspersed with other home activities. As a whole, the usage of power management functionality is well under maximum, and the reasons for it are not always clear.
- The “Wake up” from an energy saving mode can be perceived as an uncertainty factor. Many users have experienced computer instability after an incorrect wake up. Often the only cure to it has been a reboot, at the worst case causing loss of data. This could be an explanation for “Display off”-acceptance (well established and experienced as safe) and the non-acceptance for “Hard disks off”, “Sleep” and “Hibernate” functions.

1.4.2 Usage modes

- Normally “Off” means “Soft Off”, i.e. the operating system or the power button on the computer is used to turn it off. This does not mean that the power consumption goes down to zero [ENERTECH, 2005]. It is indeed drastically reduced, but remains around 3 W.
- Computer manufacturers often make a major difference between “Active” and “Idle”, and even some states in-between. For their purposes it is

clearly motivated, but not from the user perspective. Consequently, for the current purposes, both concepts are used as equivalent and named "Active".

- Some of the companies gave suggestions on figures for usage pattern. The data given are included in our calculations, but cannot be presented individually due to confidentiality reasons.

1.5 Estimation of usage pattern, based on collected data from the studies and answers presented

When calculating the usage hours, it has to be taken into account that office and home computers are used very differently during weekends.

The following summary, table 4 shows the mean values of the data from all sources presented earlier. There are some limitations to consider:

- It has not been possible to get information for all use cases from all reports and manufacturers. Even if not stated, the sample size varies for different usage modes, as not all sources consider all modes, and the accessible information forms a rather sparse matrix. When adding up all sources, this leads to usage times that most often do not add up to 8760 hours per year. Consequently, usage times are normalised to that value.

- Most information was originally produced for other purposes, only matching partially the current requirements. All information does match the same quality standards. Not being in position to weight the data for quality, a non-weighted average have been used.

Table 4. Computer usage pattern, mean values from all sources

Computer usage pattern			Normalised time [hours/year]	Percent
Desktop	Office	Off	3285	37
		Sleep	3196	36
		Active	2279	26
	Home	Off	4057	46
		Sleep	3354	38
		Active	1349	15
Laptop	Office	Off	3153	36
		Sleep	2995	34
		Active	2613	30
	Home	Off	4258	49
		Sleep	3280	37
		Active	1222	14
Monitor	Office	Off	2375	27
		Sleep	3798	43
		Active	2586	30
	Home	Off	4244	48
		Sleep	3514	40
		Active	1003	11

”**Off**” includes soft off (computer turned off by software or power button but still connected to mains) and hard off. The latter occurs very rarely.

“**Sleep**” includes several low energy consumption states, none of them permitting interactive usage.

“**Active**” includes all power states between idle and high (maximum power usage).

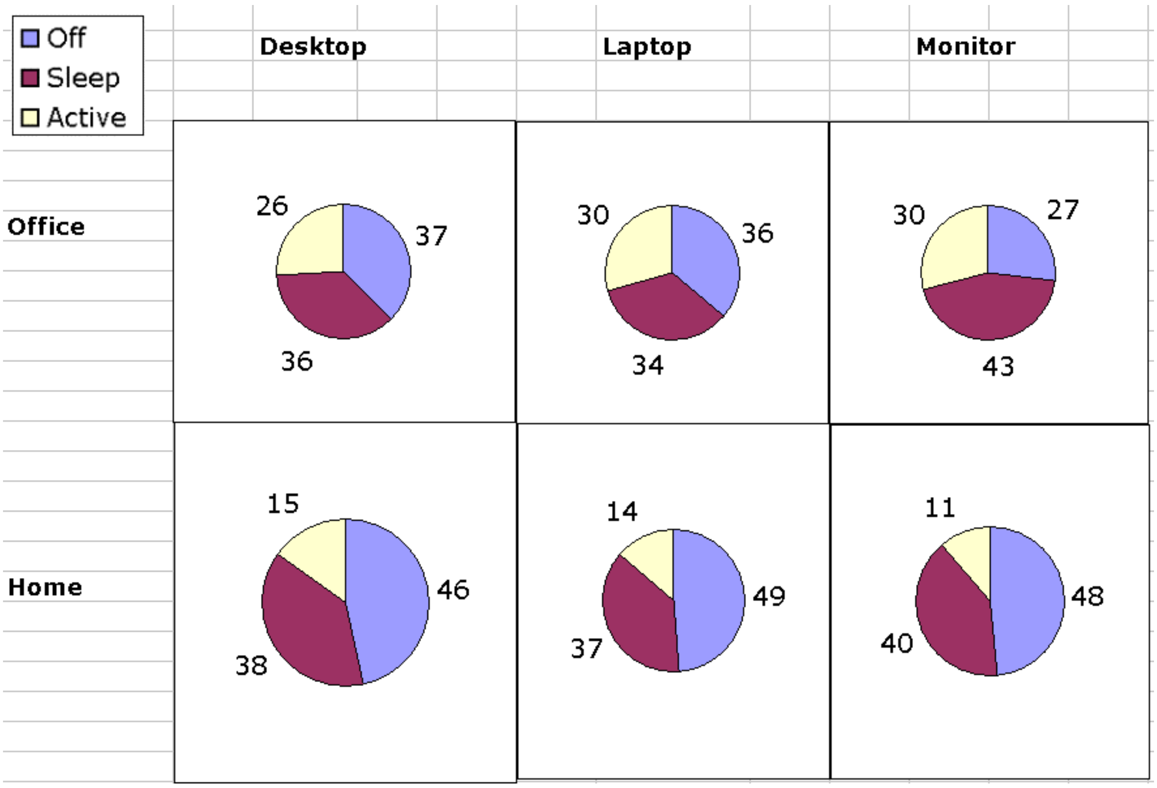
1.6 Conclusions regarding usage pattern

Office computers are in active use during less than one third of the time. For home computers this value is less than one sixth. The rest of the time is sleep and soft off. The off time is about one third of all available time, which is less than the time out of office. Hard off time is negligible.

The active time is assumed to correspond to active usage. For the rest of the time there is a tendency towards higher processor activity levels than necessary, i.e. sleep when it could be hibernate or off, soft off when it could be hard off.

For home computers, the off time is longer than for computers in office use. In relation to the relatively limited active time, the sleep time is dominating.

Most users, both at office and home, are unaware of the difference in energy consumption between soft off and hard off.



2 End of Life behaviour

2.1 Economical product life

Computers and monitors are usually not replaced due to being worn out or broken, but due to increased demands for functionality, often triggered by new versions of software. In the survey, the stakeholders were asked for the expected lifetime ***in use*** for the different products within this study. It was rather amazing to find out that most products are stored, for example in the garage, for some years after use before they are sent to the End of Life treatment organisation.

The table below shows the average economic lifetime for the "first life" of equipment, calculated as mean values of the answers in the survey, the number of respondents on this issue was 6. The deviations were quite large, ranging from 3,5 years to 7 years for Desktop in home use, so the averages should only be taken as indicative.

Table 5 Average economic lifetimes, of first life, opinions of the suppliers

Equipment	Average first life economic lifetime (years)
Desktop	6
Laptop	5
CRT	6
LCD	6

2.2 Repair- and maintenance practice

2.2.1 Service agreement

For the computer and monitor market, an often-used way to manage repair and maintenance costs, is to buy a service agreement. An example of that is (from one of the companies answering our survey) if a company buys a 1000€ computer set (computer and monitor), they often pay about 200€ for a 3 year service agreement, where ALL repair and maintenance costs are included. The same kind of agreement is also available for private consumers who can pay approximately 120€/year for the same kind of service. The costs do differ from small to big customers and also depend on where the equipment is located and used. Quite often these service agreements are included in the purchase prices.

2.2.2 Upgrading

Desktop computers can be upgraded to give better performance by adding more memory, by changing or adding hard disks, and by changing graphics cards. The logic for upgrading is in the first two cases basically the effects of the continuously improving price/performance relationship, while the upgrading of graphics controllers is driven by new functionality needed, especially for gamers. Upgrading is an opportunity sometimes used by private consumers, but more seldom by professional users. The survey gave some figures saying approximately 2% of the customers use that opportunity. We assume that the cost for an upgrade is about 200 €.

For Laptops, the only realistic upgrade is adding more memory, and replacement of worn out batteries, while monitors leave no opportunity for upgrades.

2.2.3 Repair

Computers

Also customers without service agreements do repair their computers when they break. Figures for repair costs were very difficult to find, but interviews with some computer repair companies (who wanted to be anonymous in this report) gave some indications. An ordinary repair cost is about 75€ for labour for identifying and changing broken hardware. The costs for the spare parts differ, but are often somewhere between 50 and 150€. We assume every computer need one repair at a cost of 125€ in its life time. Some repairs are also made within the warranty time.

Monitors

Monitors mostly have a three-year warranty, within which time broken monitors are repaired for free. The repair cost for a monitor is often about 120€ which is far too much to pay for repairing a monitor older than 3 years, it is often more economical to by a new instead.

Software

A quite common repair and maintenance behaviour for computers is to upgrade the software or adding on new software applications. A study referred to by Tim Landeck [Total Cost of Ownership] claims that the initial purchase price for hardware and software is approximately 16% of the Total Cost of Ownership of a computer.

The computer repair companies say that they often reinstall software, such as the operating system at a cost of approximately 75 €. The costs for software will not be included in the calculations, according to the VHK-methodology.

2.2.4 Conclusions regarding repair and maintenance

In the calculations in the subsequent tasks, we will use the following figures: Repair and maintenance cost, 200€ for a computer. No extra cost for a computer monitor. Maintenenance, repair and service transportation is assumed to be 40 km per product. The VHK methodology do add 1% material for spare parts, which is a good assumption for this kind of products.

2.3 Present fractions to recycling, re-use and disposal

The end of life behaviour regarding computers and monitors will be very much influenced by the WEEE directive. (For more information, se task 1 and 2.) The WEEE directive puts the responsibility for Waste of Electric and Electronic Equipment on the producer. That means that in a post-WEEE situation there will be no added cost for the consumers at disposal time. Today the situation differs quite a lot from country to country, and even from region to region within countries.

The producers within our survey are also handling end of life treatment differently. Some of them have made agreements with collecting and recycling companies, country by country. Some have built their own systems to gather and treat the products after life. All customers will have the opportunity to get rid of their equipment for no extra cost. Sometimes the customers have to bring the equipment to specific places to get rid of it, and sometimes they only need to make a phone call and the waste will be collected at the door. The WEEE directive is implemented in the major part of EU and is under implementation in the rest of EU25.

The WEEE directive quota at time of disposal for products covered by this study, is 75% recovery and 65% recycling.

When asking the companies about the fractions for recycling, re-use and disposal the answers differ, but the main conclusion is that almost all parts of the products are (or will be when WEEE is implemented) possible to re-use, recycle or bring to "incineration with energy recovery". Only about 2 % will be disposed. A small part of the products will go to destruction (dangerous materials need to be destroyed, for example by extra hot incineration)

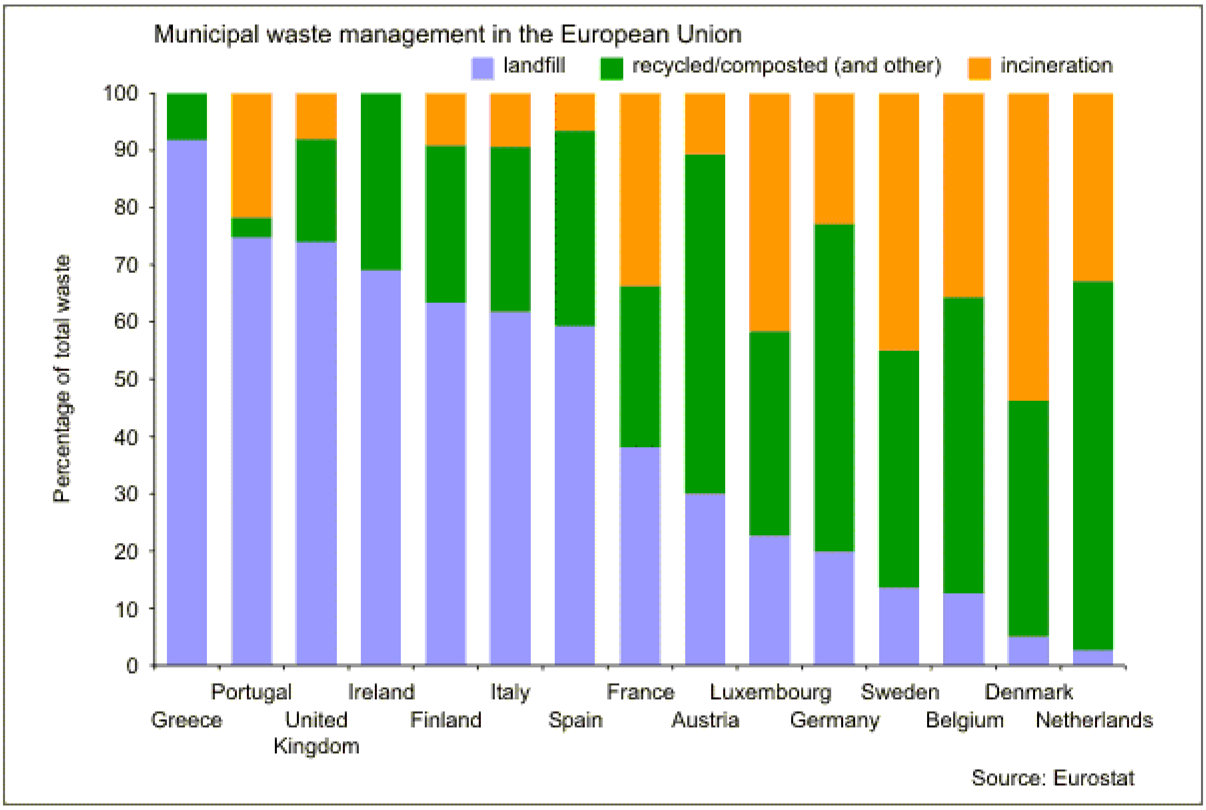
According to a telephone interview with Johan Herrlin, Stena Technoworld [2006] the waste from computers and monitors collected in Sweden 2005 (according to the producer responsibility law introduced 2001) distributes to the different waste fractions as follows:

- 80 % recycling to new material
- 15 % Incineration (energy recovery)
- 1 % Destruction
- 4 % Deposition

For the countries not yet following the WEEE directive, the estimate is that people follow the main stream of municipal waste in the countries, also when getting rid of electronics (see fig.1).

Figure 1 Municipal waste management in the European Union 2003

EU-15



It is estimated that around 580 kilograms of municipal waste was produced in average by each person in the EU-15 countries in 2003.

Greece landfills over 90% of its municipal waste, and Portugal and the United Kingdom landfill around three quarters of their municipal waste. The Netherlands and Denmark dispose of almost no municipal waste to landfill, while Belgium, Sweden, Germany and Luxembourg all landfill less than a quarter of their municipal waste.

In Denmark, Sweden and Luxembourg incineration is the single main method of disposal and over half of Denmark's municipal waste is treated in that way. The Netherlands and Austria recycle/compost around 60 per cent of their municipal waste, and Belgium and Germany recycle/compost around half of theirs.

Note 1: Only broad comparisons can be made between countries because of differences in definitions of types of waste management. The recycling category includes some other recovery options (fuel manufacture, for example), which are negligible in most countries, but account for about 10 per cent of municipal waste in Germany, and 6 per cent in Spain.

Note 2: EU-15 refers to the 15 members states of the European Union in the period prior to enlargement in 2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. [Eurostat environment waste statistics]

This figures are only given to give a hint about the present situation, the study shall use a past-WEEE scenario in the calculations.

2.3.1 Conclusion

The recovery rate (for recycling, energy recovery, ect) in the VHK methodology is assumed to be 95% that is used as default figures in the Ecoreport tool. It is supposed to give a past-WEEE picture. This is close to the figures from the well-developed WEEE system in Sweden, and will therefore be used in the calculations in this study.

2.4 Estimated second hand use, fraction of total life time and estimated second product life

The answers in the survey regarding second product life also differ a lot. The main findings are though, that there are significant volumes of products used in a second life. The second life can be estimated to be about half of the first life time described above for the different product groups. The more valuable the equipment is, the more likely it is that it will have a second life. Before the second life the products are often refurbished. About 20 % of the equipment is estimated to have a second life now, but the percentage will increase to 30% within some years according to a Swedish study [Bengt-Erik Svensson and Carl-Olof Andersson 2004]. This study also shows that the products in their second life often are used in schools, given to development agencies (e.g. SIDA) or sold to developing countries.

2.4.1 Conclusions second second hand use

In the calculations in the subsequent tasks, we will use that 20% of the products will have a second life of 3 years, leading to the following total life:

Table 6 Average total life time

Equipment	Average economic lifetime (years) including second life
Desktop	6,6
Laptop	5,6
CRT	6,6
LCD	6,6

2.5 Best practice in sustainable product use

Computers and monitors are used for a large variety of purposes and under many different usage patterns. The use of computers and monitors is highly dependant on the software. The common operating systems, like Microsoft XP, and most virus protecting softwares offer the possibility of automatic updates over the Internet. It is common to schedule such updates to times when not actively using the equipment, thus generating a tendency to leave it on, even over night.

New ways of communication, such as “chat”, voice over IP, “MSN” and other, also imply 24 hours usage. For many such applications, constant monitoring of the incoming data packages on the network is essential. An effective functionality for using energy saving modes while actively listening to the net, is becoming more and more important.

Very time consuming booting procedures, generated by more complex software and more complex linkages in networks, discourage users from turning off the equipment. In office environment it is common to add to the boot procedure an extensive virus scan, synchronising of documents, and recreating connections to network disks and printers.

To create a “smart” (sustainable and high performance) usage pattern, the functionality of software such as the operating system is central, to allow the energy saving functions to be activated much more frequently.

Some of the most important best practices in sustainable product use are collected from information from our stakeholders.

2.5.1 Power management

Power management is a software tool making the computer and/or monitor use less energy by going into power saving modes, when less computing activity is needed. Power saving can be implemented in several ways, like turning the fans off when less heat is generated, stopping the disks from spinning after a certain time of inactivity, reducing power to the CPU when at less activity and even turning the motherboard off for all functions except waiting for interrupts.

The most modern standard, *The Advanced Configuration and Power Interface ACPI* specification, see reference [ACPI, 2006] is an open industry standard first released in December 1996 developed by HP, Intel, Microsoft, Phoenix and Toshiba that defines common interfaces for hardware recognition, motherboard and device configuration and power management. According to its specification, "ACPI is the key element in Operating System-directed configuration and Power Management (OSPM)". The older standard APM made power management to be put under control of the BIOS (the basic built in firmware), which gave much less room for efficient energy usage.

Although modern computers are equipped with these advanced functions for power management, they are often disabled in standard installations of software, especially in office network environments. As indicated in the article above, integration of legacy software, not built for APCI can cause problems, which has generated a suspicion for problems among many IT-departments.

According to [TIAX LLC, 2004] "Network software that enables power management for networked office equipment has the greatest energy savings potential of all the measures selected for further study, i.e., applied to all relevant equipment it could reduce total annual energy consumption by 21 to 30 percent. This reflects the relatively low power management-enabled rates of office equipment as well as the large differences in power draw between active and low-power modes." According to the same report, desktop PCs have a 6% to 25% PM-enabled rate.

Application of WOL (Wake on LAN), a functionality to allow booting triggered from the network, can be a solution for a more sustainable management of office networks, especially for the sake of software upgrades during non-working hours. In the latest Energy Star specification, WOL functionality is required or alternatively the ability to monitor the net in sleep mode.

2.5.2 Hard off switch

Most products use some energy even if they are switched off by the software (soft off). Most users are not aware of the difference between a soft off, putting the equipment in standby and a hard off (physically disconnecting). A best practise usage pattern could be to making hard off a habit, whenever the start-up time is not generating an inconvenience.

2.5.3 Customer information

Computers and monitors are very sophisticated equipment, making it difficult for people to understand how to use the products in a sustainable way. It is therefore of importance to give customers relevant information, regarding how to use power management, how to switch off the product, how to treat the equipment after use (End of Life treatment) and other important information. Some products include good information in this respect; while other producers do not supply that kind of information at all. The "white box" sector has special difficulties regarding information. "White box" products are products assembled from standard components by small local companies, sometimes with their own brand. These companies seldom provide information on how to treat the products in a sustainable way.

2.5.4 Change to a more sustainable product

Some techniques are more sustainable than others. One example is the LCD monitor, which uses much less energy than the CRT for the same size of screen. Another way for the customer is to choose equipment, which fulfils the requirements from voluntary labelling schemes, such as Energy Star or TCO labelling scheme.

2.5.5 Sustainable End of life treatment

Most manufacturers do have a good system for End of life treatment, either internally, or by an agreement with another company. It is of importance that computers and monitors do come to a WEEE-compatible end, which is also the case in many countries.

3 Local infra-structure

Computers and monitors are more or less dependent on two main infrastructure systems, electricity and Internet. These are described below.

3.1 Electricity availability

One absolute requirement is electric supply, which is available all over Europe to all households. It is also becoming even more available, for example on trains and other transports, making it possible to connect and use equipment when travelling.

For sensitive computer installations or in areas with frequent interruptions of the electrical supply, it is common to protect the equipment by installing Uninterruptible Power Supplies (UPS, “battery backup”), to allow undisturbed usage for a limited time during power failures.

In environments with other kind of disturbances in the power distribution, frequency and amplitude variations, other types of filtering devices are used to improve the conditions for computer installations.

3.2 Internet

3.2.1 Internet availability

Internet is the other infrastructure of importance for computers and monitors. Even if standalone computers still exist, the computer has become more and more a communication machine. Modems have been common for many years now, allowing low speed call up connections to the Internet. Nowadays broadband is more and more common, which makes computer communication much faster, and often to a fix cost independent of traffic volume. The increasing bandwidth opens up for new applications and new ways to use computers, making it the centre for communication.

The Internet connectivity opens up for a number of new applications, all pointing to changes in usage patterns with more active on time, especially in home environment. Such new applications are: Voice over IP, TV over broadband, downloading of music and film and so on. It is still to be seen, whether all of these new applications will be used on general purpose PCs or on special devices. The power management usage in such network dependent applications is in its turn highly dependent on the operating system, as explained in earlier chapters.

The establishment of WLANs and hotspots at public places make it even more important to allow fast start-up from off state, or very effective power management. For laptops, the customers will certainly make this a buying parameter, to gain long battery working time.

In September 2006 the Internet penetration was 239 881 917 users in EU25, with Benelux and the Nordic countries leading the way and eastern and south Eastern Europe generally lagging behind. [Eurostat Internet penetration] In Sweden, Denmark and Finland over 80% of firms have broadband access, compared to less than 45% in Cyprus, Poland and Greece.

The level of Internet access is lower in sparsely populated rural regions (40%) than in heavily populated urban areas (52%). Students are on proportion the most regular Internet users. By contrast, 48% of unemployed persons claimed never to have accessed the Internet. Another interesting tendency is that women in Europe increased their Web usage at a faster rate than men in the past three years, according to a report published by the European Interactive Advertising Association http://www.eiaa.net

Table 6: Internet usage in Europe, data from Eurostat

Internet Usage in Europe						
EUROPE	Population (2006 Est.)	% Pop. of World	Internet Users, Latest Data	Penetration (% Population)	% Usage of World	Use Growth (2000-2006)
European Union	462,371,237	7.1 %	**239,881,917**	51.9 %	22.1 %	157.5 %
EU Candidate Countries	110,206,019	1.7 %	**24,983,771**	22.7 %	2.3 %	622.1 %
Rest of Europe	234,711,764	3.6 %	**43,847,215**	18.7 %	4.0 %	417.5 %
TOTAL EUROPE	807,289,020	12.4 %	**308,712,903**	38.2 %	28.4 %	193.7 %
Rest of World	5,692,408,040	87.6 %	**777,538,000**	13.7 %	71.6 %	203.9 %
TOTAL WORLD	6,499,697,060	100.0 %	**1,086,250,903**	16.7 %	100.0 %	200.9 %

NOTES: (1) European Internet Statistics were updated on Sept. 18, 2006. (2) Population is based on data contained in world-gazetteer.com. (3) The usage numbers come from various qualified sources, mainly from data published by Nielsen//NetRatings , ITU , and other trustworthy sources. (4) Data may be cited, giving due credit and establishing an active link back to Internet World Stats .

As can be seen from the tables above, the internet usage is expanding rapidly, thus also giving the indication toward more "on-time" for computers, as discussed earlier.

3.2.2 Internet usage

The Internet usage is also studied, which gives a hint of the computer usage pattern.

According to data released by comScore Networks's (http://www.comscore.com/) new World Metrix panel. The worldwide average number of hours spent online in the month of March 2006 was 31.3 hours a month. The top 15 countries include Israel (57.5 hours), Finland (49.3 hours), South Korea (47.2 hours), and the Netherlands (43.5 hours). The following are the top countries on broadband use:

Table 7. Average monthly online hours per unique visitor by country, March 2006

Average Monthly Online Hours per Unique Visitor by Country, March 2006	
Country	**Avg. Hours per Visitor March 2006**
Worldwide	31,3
Israel	57,5
Finland	49,3
South Korea	47,2
Netherlands	43,5
Taiwan	43,2
Sweden	41,4
Brazil	41,2
Hong Kong	41,2
Portugal	39,8
Canada	38,4
Germany	37,2
Denmark	36,8
France	36,8
Norway	35,4
Venezuela	35,3
Note: Visitors are 15 years old or older,	
Source: comScore World Metrix, 2006	

The numbers of Internet users in Europe roughly corresponds to the number of computers in use (installed base), in previous chapters. But the usage patterns in table 4 indicate that the average computer is in active mode 2 to 4 times as much as the time connected to the Internet. This shows that there is still a lot of use for other applications than Internet access.

Experiences indicate that WLAN installations are more sensitive for computers not actively participating in the network traffic, thus contributing to the practice of disabling power management.

3.3 Barriers for new technologies/products

Barriers for new technologies/products are gathered, mainly through the IVF industrial survey [2006]. Some of the most important quotations on barriers for new technologies/products from the answers of the questionnaire received from stakeholders are presented below. They are divided into three levels, consumer level, company level and system level.

3.3.1 At the consumer level

- "Cost, value added must be clearly demonstrated"
- "Price and product weight for Laptops"
- "Consumers focus on cost and performance rather than energy efficiency"
- "Consumers typically don't know what they want beyond a 6-12 month horizon. Until an industry 'innovator' demonstrates what is possible, the consumers act within their existing experience base. The number of true industry innovators is decreasing as the market continues to commoditize"
- "Regional/economical/political directives/regulations"
- "Product understanding/use"
- "General resistance to change. Hassle/time/expense needed to upgrade associated software etc, Difficulty of being an early adopter (no software available, technology maturity problems). Cost of being first (both to the manufacturer and the consumer)"
- "Price, easiness of use, belief in the new technologies"

3.3.2 At a company level

- "Cost, the customer must be willing to pay. Another important barrier at our company is the level of standardization. Our company only design and markets products, which are at a high level of standardization"
- Most PC OEM's (component manufacturer) have turned into marketing focused distributors that rarely invest in technology innovation, choosing instead to focus on business model innovation."
- "Economic"
- "Lacking clear and consistent signals and awards from customers including public sector, innovative programs that would meaningfully

award manufacturers, lack of aggregation of public sector purchasing power (e.g., across EU-25)"

- "Price, compatibility with existing software and network, ability for IT staff to support product"
- "Company regulations, skills shortage, funding/financing"
- "Financial cycle (amortization) "
- "Legacy architecture support"
- "Proprietary application portability"
- "Proof of reliability required"
- "Technical compatibility"
- "Risk of missing the market by being too late or too early (causes business disruption). Cost of upgrading/deployment/infrastructure changes/training. Need for stability/uniformity of installed base"

3.3.3 At a system level

- "The PC market is a commodity market, which follows a 'waterfall' model. Typically new technologies come into the market at the highest price points and migrate over time to lower price points. There are some technologies (typically reserved for mobile uses) which will never meet desktop price points due to the tax of miniaturization"
- "Fear of adopting technology until a clear industry standard emerges (e.g. 802,11N, USB, Firewire, etc.). Lack of customer demand for new features/technology. Lack of infrastructure to support new technology (e.g. fiber optic networks/gigabit network equipment), Legal/licensing/patent uncertainties (e.g. duplicating music, CDs, using a competitors patented technology)."
- "Immature technologies"
- "Need for interoperability (globally) for hardware and software. Lack of standards/compatibility"

3.3.4 Conclusion regarding barriers

The answers from stakeholders show that they think the main barriers for customers on new technologies/products are related to cost/performance. At the company level there are also much cost related thoughts, but also a fear of introducing new solution at the wrong time. The hardware must be able to harbour several different generations of software also old ones, thus there are certain limits for disruptive developments. At the system level, it seems that most producers feel a lack of standards. An interesting thing is that the answers were so similar and in agreement. Still it is of importance to notice that the answers are gathered from industry, and that there might be other barriers for new technologies/products within the society.

4 References

- Monitoring Home Computers [AEA Technology, England, 2006] (Unpublished)
- TECHNOLOGIES DE L'INFORMATION ET ECLAIRAGE - Campagne de mesures dans 49 ensembles de bureaux de la Région PACA [ENERTECH, France, 2005]
- Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings, prepared by TIAX LLC for U.S. Department of Energy [TIAX LLC, 2004]
- U. S. Residential Information Technology Energy Consumption in 2005 and 2010 [TIAX LLC for U.S. Department of Energy, USA, 2006]
- EEDAL'06 (International Energy Efficiency in Domestic Appliances & Lighting Conference '06 [Kurt Roth, TIAX LLC, USA, 2006]
- EEDAL'06 (International Energy Efficiency in Domestic Appliances & Lighting Conference '06 [Karine Thollier, Institut de Conseil et d'études en Développement Durable, Belgium, 2006]
- Förbättrad energistatistik för lokaler – "Stegvis STIL" Rapport för år 1 [Statens energimyndighet, Sweden, 2005]
- Sustainable Products 2006: Policy Analysis and Projections [www.mtprog.com , UK, 2006]
- Vart tar watten vägen? [Institutionen för Värme- och Kraftteknik, Lunds Tekniska Högskola, Sweden, 2003]
- Residential computer usage patterns, reuse and life cycle energy consumption in Japan [Eric Williams, United Nations University and Takuro Hatanaka, Mizuho Securities, Japan, 2005]
- Barbara Schlomann et. al. Technical and legal application possibilities of the compulsory labelling of the standby consumption of electrical household and office appliances. Fraunhofer ISI, 2005
- Energy Star energy calculator http://www.eu-energystar.org/calculator.htm
- Eurostat municipal waste http://www,defra,gov,uk/environment/statistics/waste/kf/wrkf08,htm

- Eurostat internet penetration: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NP-06-012/EN/KS-NP-06-012-EN.PDF

- European Interactive Advertising Association <http://www,eiaa,net> Women (EIAA)'s Mediascope Europe unit

- Tim Landeck [Total Cost of Ownership] http://www.thesnorkel.org/toolkit/articles/TCO_Final%20.pdf.

- Reuse IT-products, Perspicuous survey, [Bengt-Erik Svensson and Carl-Olof Andersson, Commission for El-Kretsen AB, October 2004]

- IVF Industrial Survey, 2006. Several stakeholders did answer the questionnaire from IVF during the summer 2006. Due to secrecy agreements, they are not named here, but the list covers the main players for both computers and monitors, also covering companies from Europe, the USA and Asia. The number of respondents to the questionnaire was 16.

- Telephone meeting October 2006 with Ph.D. Magnus Bergquist, ethnologist
  Associate Professor
  Dep. of Applied Information Technology
  IT University, Göteborg
  http://www.ituniv.se/

- Telephone meeting October 2006 with Catriona McAlister
  ICT Product Manager
  Market Transformation Programme
  AEA Environment
  Glengarnock Technology Centre
  http://www.aeat.co.uk/
  [AEA, 2006]

- Telephone meeting, October 2006 with Johan Herrlin at Stena Technoworld. http://www.stenametall.com

- ADVANCED CONFIGURATION AND POWER INTERFACE SPECIFICATION
  Revision 3.0b, October 10, 2006
  http://www.acpi.info/spec.htm