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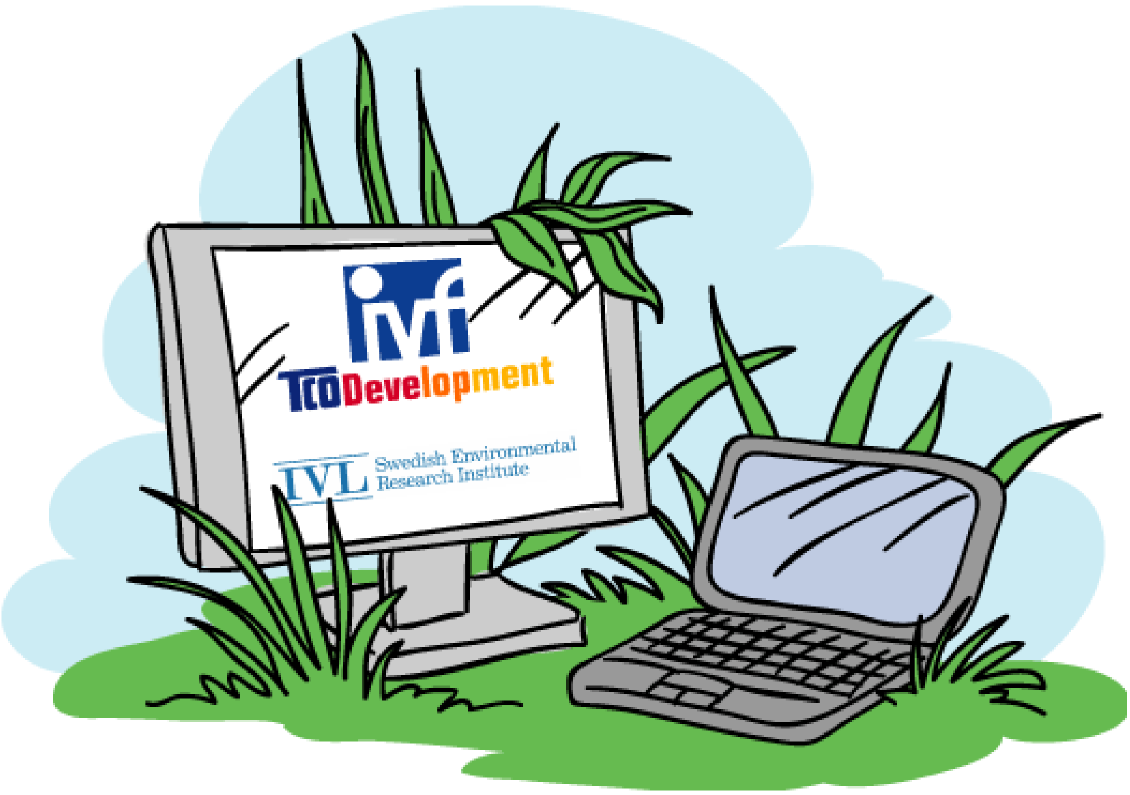
Lot 3
Personal Computers (desktops and laptops) and Computer Monitors

Final Report (Task 1-8)

IVF Industrial Research and Development Corporation



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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 final report within the EuP preparatory study, Lot 3, Personal Computers (desktops and laptops) and Computer Monitors, covering tasks 1 – 8.

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.

The report is made available to all stakeholders, through the web-page www.ecocomputer.org

Some information for the reader of this report:

- Abbreviations are described at the end of the report
- The chapters are called task 1-8 in order to follow the VHK-methodology
- References are placed at the end of each task
- Stakeholder feedback on earlier versions of the content of this report is collected and described in appendix 4.

Finally, we would like to use the opportunity to thank all the people and organisations contributing to this study by giving data and/or feedback comments. Thank you!

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Summary

The VHK-methodology has been the base for this report on EuP preparatory study, Lot 3, Personal Computers and Computer Monitors. Information has been gathered from available research, but also from other sources, such as from industry and other stakeholders. The main results are described here, for more details, se the tasks described further in the report.

Task 1, product definition, shows that there are several labelling schemes for the product group, with Energy Star as the most important for computers and monitors and TCO for monitors. The product definition chosen is based mainly on the Energy Star definition, and includes desktops, integrated computers, laptops and computer monitors. Note that workstations, desktop-derived, mid-range and large servers, game consoles, thin clients/blade PCs, handhelds and PDAs are out of the scope of this study.

Task 2, Economic and Market analysis, shows that the installed base in EU-25 of the products within this study in 2005 were approximately; 146 million desktops, 60 million laptops, 81 million CRT-monitors and 68 million LCD-monitors.

Task 3, Consumer behaviour and local infrastructure, shows that even if the usage pattern is of great importance for this kind of products, it is not especially well described in research. The usage patterns differ between home and office use, but is also depending on other things, such as age, Internet penetration etc. The average usage pattern suggested to be used for the calculations in this study, is for desktops in office 37% of time in off-mode, 36 % of time in sleep mode, and 26% of time in active mode. More research into usage patterns could improve the accuracy of the estimations considerably.

Task 4, Technical analysis existing products, gives the major technical information, such as the “Bill of material” for the product cases chosen. For Desktop PC the following characteristics have been used: 3 GHz processor (or correspondingly), built-in graphics card, 512 MB RAM and 80 GB HDD; Laptop, characterized by mobile 1,7 GHz processor (or equivalent), good 3-dimensional graphic performance, 15”-screen, 512 MB RAM and 60 GB HDD; for LCD display: 17”, resolution 1280*1024; and for CRT display, 17”.

Task 5, Definition of base-case, shows the result in terms of environmental and cost impact for the base cases calculated with the Ecoreport tool. For all the product cases, energy use during the use phase is of highest importance.

Task 6, Technical analysis BAT (Best available technology) describes the major technologies of importance to further improve the environmental performance of the product group. Improvements such as power management, high efficiency power supply units and improved processors are described in detail.

Task 7, Improvement potential, where the impact of the improvement options are calculated in the Ecoreport tool, shows a great potential for improvement. If the improvements giving the least life cycle cost (LLCC) were used for the products

in use in EU 2005, the potential for saving global warming gases would be approximately 10 mega tones CO2eq annually.

In Task 8, Scenario-, Policy-, Impact-, and Sensitivity analysis, some future scenarios, such as Business as Usual and scenarios with different implementing measures are described and the impact on total energy use estimated, calculated and compared for the time until 2020. Total energy use in the future by the product groups described in this study is very much depending on the market development (how many products will be used) and on the usage pattern (which is changing very much over time), why the absolute values are quite rough. Still the sensitivity analysis shows that the conclusions regarding improvement options providing a better environmental performance with a lower life cycle cost are robust.

1 Product definition

Introduction

In task 1 of this study the products within the study have been defined by looking at how personal computers and monitors are defined and categorized in trade statistics, relevant standards and voluntary initiatives. Also the existing legislation and its impact on the product categories have been studied.

The objective of this part of the study and the report is to describe the definitions and the background of the assessment that will be carried out in subsequent parts of the study. The methodology developed by VHK for the European Commission (MEEUP 2005) is followed.

To delimit the "playing field" of eco-design there is a need to define what is included in *personal computers and computer monitors.* The product definition that will be used in this study and is described in this section takes its starting point in the name of Lot 3, "*Personal Computers (desktops and laptops) and Computer Monitors".*

1.1 Historic perspective

Personal computers and computer monitors are quite new products in society. They first started to come out on the market in the eighties. Since the introduction of personal computers, there has been a tremendous development of the products. Moore's law, which is a prediction made by Gordon E. Moore in the sixties that the processor speed will double every 18th month, still holds true.

One reason for the rapid development of the personal computer is that a PC has always been made with standard components developed mainly by sub-suppliers and sold by retailers. This has created a very dynamic sector because there are business opportunities for many different actors.

The fast development of the product group could, from an Eco-design perspective be both a threat and an opportunity. The threat is that so much development is done in a short time, and people are so eager to find new fancy solutions, that the consequences of the development might not be enough scrutinized. The great opportunity is that the products are not yet fixed by too much tradition, thus giving product design a major playing field in functionality and implementations. Already today, personal computers are combined with mobile phones, home media centres and other kind of products. Monitors can also be a TV-set or perhaps in the future the new wall painting?

There is no universally accepted definition of the term personal computer. Most people seem to agree that a personal computer is relatively cheap, multi-purpose, based on microprocessors, designed as a single-user system and usually very flexible regarding which operating system, hardware and application platform it can be fitted with.

1.2 Market data definitions

1.2.1 Eurostat

The basic information available in Eurostat gives rough numbers for production, import and export, which then makes it possible to calculate the net numbers of new equipment brought into use by taking new = production + import - export. To calculate the installed base, the average life-time in use must be estimated (the manufacturers have been asked for estimates).

In Eurostat, there are two registers (data-sets), which basically contain similar data, PRODCOM and COMEXT. PRODCOM is the most important for this study, since COMEXT has no data on production. The data in PRODCOM is organised according to product codes. Some of the codes have changed over time, which makes it necessary to use the data as the union (sum) of data on several codes.

In the Eurostat (Prodcom/comext) statistics, computers and monitors are classified as follows:

1 30021200 Laptop PCs and palm-top organisers

2 30021300 Desktop PCs (including integrated computers)

3 30021400 Digital data processing machines: presented in the form of systems

4 32302083 Black and white or other monochrome video monitors

5 32302045 Colour video monitors with cathode-ray tube (CRT)

6 32302049 Flat panel video monitor, LCD or plasma, etc., without tuner (colour video monitors) (excl. with cathode-ray tube).

1.2.2 Market data and base cases

The VHK-methodology states that the product categories to be assessed in base cases must be possible to identify in the market figures. This complicates the study, since the VHK-methodology also point out Eurostat as the source for market information, and Eurostat has very poor categorisation and market information for this kind of products.

The main weaknesses of the data in PRODCOM are:

1 Data for the different countries are only available from their entry into EU

2 For countries with few manufacturers, the production figures are hidden due to rules within Eurostat (competitive secrecy). This means that some

countries show negative values for new equipment. An application to get hold of the hidden data was sent to Eurostat, through their Swedish representative (SCB), but it was denied.

Since there are weaknesses in the EUROSTAT information, industry has been asked to provide the project with complementary data and data sources. These sources and data will be evaluated and reported in subsequent tasks.

1.3 Energy star definitions

Energy Star is one of the most important voluntary initiatives regarding products covered by this study. It is widely used both in the USA and the EU, it is agreed upon within a wide group of stakeholders, and the definitions are well developed. More information about the Energy Star initiative will follow in the chapter called "Voluntary agreements" in this report. The definitions used by Energy Star are:

1.3.1 Computers

The Energy Star Program Requirements for Computers: version 4.0

A device, which performs logical operations and processes data. Computers are compose of, at a minimum: (1) a central processing unit (CPU) to perform operations; (2) user input devices such as a keyboard, mouse, digitizer or game controller; and (3) a display screen to output information. For the purposes of this specification, computers include both stationary and portable units, including desktop computers, gaming consoles, integrated computers, notebook computers, tablet PCs, desktop-derived servers and workstations.

The computers are in the Energy Star program divided in the following type definitions:

1 ***Desktop Computer***
A computer where the main unit is intended to be located in a permanent location, often on a desk or on the floor. Desktops are not designed for portability and utilize an external monitor, keyboard and mouse. Desktops are designed for a broad range of home and office applications including, email, web browsing, word processing, standard graphics applications, gaming, etc.

2 ***Desktop-derived server***
A desktop-derived server is a computer that typically uses desktop components in a tower form factor, but is designed explicitly to be a host for other computers or applications. For the purposes of this specification, a computer must be marketed as a server.

3 ***Game consoles***
Stand alone computers whose primary use is to play video games. For the purposes of this specification, game consoles must use a hardware architecture based on typical computer components (e.g. processors, system memory, video architecture, optical and/or hard drives etc.) The primary

input from game consoles are special hand held controllers rather than the mouse and keyboard used by conventional computer types. Game consoles are also equipped with audiovisual outputs for use with televisions as the primary display, rather than an external monitor or integrated display. These devises do not typically use a conventional operating system, but often perform a variety of multimedia functions such as DVD/CD playback, digital picture viewing, and digital music playback.

4 ***Integrated Computer***

A desktop system in which the computer and display function as a single unit, which receives its ac power through a single cable. Integrated computers come in one of two possible forms: (1) a system where the display and computer are physically combined into a single unit; or (2) a system packaged as a single system where the display is separate but is connected to the main chassis by a dc power cord and both the computer and display are powered from a single power supply. As a subset of desktop computers, integrated computers are typically designed to provide similar functionality as desktop systems.

5 ***Notebook and Tablet computers***

A computer designed specifically for portability and to be operated for extended periods of time without a direct connection to an ac power source. Notebooks and tablets must utilize an integrated monitor and be capable of operation off and integrated battery or other portable power source. In addition, most notebooks and tablets use an external power supply and have an integrated keyboard and pointing device, though tablets use touch sensitive screens. Notebook and tablet computers are typically designed to provide similar functionality to desktops except within a portable device. For the purposes of this specification, docking stations are considered accessories and therefore, the performance levels associated with notebooks do not include them.

6 ***Workstations***

For the purposes of this specification, to qualify as a workstation, a computer must:

a. Be marketed as a workstation

b. Have a mean time between failures (MTBF) of at least 15,000 hours based on Bellcore TR-NWT-000332, issue 6, 12/97; and

c. Support error-correcting code (ECC) and/or buffered memory

d. In addition, a workstation must meet three of the following six optional characteristics:

i. Have supplemental power support for high end graphics (i.e. PCI-E 6 pin 12 V supplemental power feed)

ii. System is wired for 4x or 8x PCI-E on motherboard in addition to graphics slot(s) and/or PCI-X support *iii.* Does not support Uniform Memory Access (UMA) graphics:

iv. Include 5 or more PCI, PCIe, PCI-X slots;

v. Capable of multi-processor support for two or more processors (must support physically separate processor packages/sockets, i.e, not met with support for a single multi core processor)

and/or

vi. Be qualified by at least 2 Independent Software Vendor (ISV) product certifications; these certifications can be in process, but must be completed within 3 months of qualification.

Product groups not covered by Energy Star include mid-range and large servers, thin clients/blade PCs, handhelds and palm-top organisers.

Definitions of different categories of desktops

For the purposes of determining Idle state levels, desktops and integrated computers must qualify under Categories A, B or C as defined below.

Category A: All desktop computers that do not meet the definition of either Category B or category C below are under Category A for Energy Star qualification

Category B: To qualify under category B desktops must have:

- Multi-core processor(s) or greater than 1 discrete processor; and
- Minimum of 1 gigabyte of system memory

Category C: To qualify under Category C desktops must have:

- Multi-core processor(s) or grater than 1 discrete processor; and
- A GPU with greater than 128 megabytes of dedicated, non-shared memory.

In addition to the requirements above, models qualifying under Category C must be configured with a minimum of two of the following three characteristics:

- Minimum of 2 gigabytes of system memory
- TV tuner and/or video capture capability with hight definition support; and/or
- Minimum of 2 hard disk drives

1.3.2 Computer monitors

Definition of computer monitors from the *Energy Star Requirements for Computer Monitors Eligibility Criteria (version 4.1).*

Computer Monitor (also referred to as "Monitor")

A commercially-available, electronic product with a display screen and its associated electronics encased in a single housing that is capable of display output information from a computer via one or more inputs, such as VGA, DVI, and/or IEEE 1394. The monitor usually relies upon a cathode-ray tube (CRT), liquid crystal display (LCD) or other display device. This definition is intended primarily to cover standard monitors designed for use with computers. To qualify, the computer monitor must have a viewable diagonal screen size greater than 12 inches and must be capable of being powered by a separate AC wall outlet or a battery unit that is sold with an AC adapter. Computer monitors with a tuner/receiver may qualify as ENERGY STAR under this specification as long as they are marketed and sold to consumers as computer monitors (i.e., focusing on computer monitor as the primary function) or as dual function computer monitors and televisions. However, products with a tuner/receiver and computer capability that are marketed and sold as televisions are not included in this specification.

1.3.3 Operational Modes, computer

The Energy Star Program Requirements for computers, version 4,0 defines three computer operational modes: idle, sleep and stand-by. These are described below.

Idle State

For purposes of testing and qualifying computers under this specification, this is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default. 4

Sleep mode

A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly "wake" in response to network connections or user interface devices. For the purposes of this specification, Sleep mode correlates to ACPI System Level S3 (suspend to RAM) state, where applicable.

Standby level (Off Mode)

The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, standby correlates to ACPI System Level S4 or S5 states, where applicable.

1.3.4 Operational modes, computer monitor

The Energy star Program requirements for Computer Monitors, Eligibility Criteria (version 4.1) defines the five operational modes for monitors described below.

On Mode/Active Power

The product is connected to a power source and produces an image. The power requirements in this mode is typically greater than the power requirement in sleep and off modes

Sleep Mode/Low Power

The reduced power state that the computer monitor enters after receiving instructions from a computer or via other function. A blank screen and reduction in power consumption characterize this mode. The computer monitor returns to On Mode with full operational capability upon sensing a request from a user/computer (e.g., user moves the mouse or presses a key on the keyboard)

Off Mode/Standby Power

The lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when a computer monitor is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Off Mode is defined as the power state when the product is connected to a power source, produces no images, and is waiting to be switched to On Mode by a direct signal from a user/computer (e.g., user pushes power switch)

Hard Off Mode

A condition where the product is still plugged into the mains, but has been disconnected from an external power source. This mode is usually engaged by the consumer via a "hard off switch". While in this mode, a product will not draw any electricity and will usually measure zero watts when metered.

Disconnect

The product has been unplugged from the mains and therefore is disconnected from all external power sources.

1.3.5 Energy Star definitions and this study

The scope of energy star is slightly different from the scope of this study. Energy star covers "all" computers and monitors, and the EuP preparatory study is limited to "personal computers" and monitors. The definitions used by Energy Star are nevertheless very useful for this study. They are agreed upon within approximately the same stakeholder group as this study, and they do aim at a larger group of products within which the products of this study are a part, and the same kind of impact (energy and/or environment). At the stakeholder workshop for the Lot 3 study in May 2006, the Energy Star was also agreed upon as one of the most important voluntary agreements for this study.

Some of the products within the Energy Star definitions are out of the scope of this preparatory study, such as Desktop derived server, Game consoles and Work stations.

Regarding the Desktop differentiation categorisations A, B and C, they might be of interest when deciding the base cases, but there are some difficulties with their potential use. The VHK methodology requires market data and usage pattern divided to the different products, which so far was impossible to find related to the categorisations A, B and C. The base definition of base case will be done in task 5 of this study.

The operational modes defined in Energy Star will be used for the definition of operational modes when looking into the consumer behavior (task3) and test procedures, since they are applicable to our study, and are agreed upon by the stakeholders.

1.4 Proposed product definitions

For the purpose of this study, the following product definition is suggested for *personal computers:*

> A device which performs logical operations and processes data. Personal computers are composed of, at a minimum: (1) a central processing unit (CPU) to perform operations; and (2) user input devices such as a keyboard, mouse, digitizer or game controller. For the purposes of this study, personal computers include both stationary and portable units, including desktop computers, integrated computers, notebook computers and tablet PCs. For further definitions of these computer categories, the Energy Star definitions are applicable.

Note that workstations, desktop-derived, mid-range and large servers, game consoles, thin clients/blade PCs, handhelds and PDAs are not included in this product definition of personal computers, and will therefore not be covered by this study.

For the purpose of this study, the following product definition is suggested for *computer monitors*:

> A commercially-available, electronic product with a display screen and its associated electronics encased in a single housing that is capable of display output information from a computer via one or more inputs, such as VGA, DVI, and/or IEEE 1394. The monitor usually relies upon a cathode-ray tube (CRT), liquid crystal display (LCD) or other display device. This definition is intended primarily to cover standard monitors designed for use with computers. The computer monitors included in this definition must have a viewable diagonal screen size greater than 12 inches and must be capable of being powered by a separate AC wall outlet or a battery unit that is sold with an AC adapter. Computer monitors with a tuner/receiver may be covered by this study as long as they are marketed and sold to consumers as computer monitors (i.e., focusing on computer monitor as the primary function) or as dual function computer monitors and televisions. However, products with a tuner/receiver and computer capability that are marketed and sold as televisions are not included in the scope of this study.

1.5 Product group performance and functional Unit

There are several benchmarking methods for computers, often used by computer magazines, where they test the performance in different type of applications, often specifically games. Unfortunately they do not really work to find out the performance of a product in a broader view, since the use of computers is so differentiated!

When using life cycle assessment, LCA, to stimulate the development of environmentally superior products, the calculations should ideally yield environmental impact per some important unit of performance. This would drive development towards products with the same (or better) performance with less environmental impact during the whole life cycle of the product.

1.5.1 Functional unit for personal computers

Since personal computers are used to fulfil so many different needs, it is impossible to find one technical performance measure that could represent all these needs in a good way. This issue was also discussed during the 30 May workshop and it was concluded that personal computers are used for such a variety of reasons that there is not one technical performance parameter that stand out enough to merit being used as the functional unit in an LCA.

Most LCA of personal computers, such as EPIC-ICT (2006), (Fujitsu 2003) and Atlantic Consultings (1998) study for the Ecolabel Unit of the European Commission, use “1 computer” as the functional unit. The EIPRO study (2006) uses “Euros of computer”. Compared to “1 computer”, “Euros of computer” reflects to an extent the technical performance, since there normally is a relation between price and technical performance. Reporting environmental impact per euro computer should in theory stimulate the development of expensive computers with low environmental impact. If one could in advance determine how many years each computer will be used, "computer year" is another possibility that also to a degree reflects the technical performance.

In this study, all calculations for computers (desktops and laptops) will initially be performed on the functional unit 1 computer (desktops and laptops). The possible use of other functional units, such as "Euros of computer" or "computer years" will be further investigated and discussed. The end results can easily be recalculated. However, one should be aware of that none of these alternatives is a perfect functional unit. There use could possibly lead to conclusions that could stifle the development of more efficient computers.

1.5.2 Functional unit for computer monitors

The functional unit for a Computer monitor used by the ENERGY STAR Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1), is Environmental impact per Mpixel. Some statistics for TCO-labelled monitors, shows that the energy consumption of computer monitors are proportional to the size of the screen (cm2). This study will use the environmental impact per product as the functional unit in order to calculate the EU-25 impact, and as a secondary performance parameter use the environmental impact related to the size of the screen.

1.6 Test standards and voluntary agreements

The general objective of this task is to describe test standards and voluntary labels related to the product categories within the scope of this study.

1.6.1 Test standards

Electrical safety standards

The electrical safety standards most commonly in use are IEC 60950, (Safety of information technology equipment), EN 60950 and the American standard UL 60950. They are all very similar and can be considered harmonized.
The safety standards have demands on electrical shock prevention and fire resistance that makes the choice of materials in the design of the computer somewhat restricted.

Electromagnetic Compatibility, EMC, standards

The EMC standards most commonly in use for computers are EN 55022, (Radiated emissions), EN 55024, (Immunity), and IEC 61000-2-2 and IEC 61000-3-3, (Disturbances on the low voltage main power supply). In the US, the FCC Part 15B class B standard is in use. The EMC standards also influence what is possible to do or not when designing a computer.

EN 62018 Power consumption for information technology equipment (ITE) – Measurement methods (2004)

This standard is adapted from IEC 62018 (2003) standard of the same name. The standard specifies methods of measurement of electrical power consumption in different modes of the use phase of ITE. It specifies the following conditions:

- configuration of the tested equipment
- environment
- power supply
- supply-voltage waveform
- power measurement accuracy
- testing instrumentation
- time of measurement
- test procedure.

Scope: Information Technology Equipment identified in more details in the standard IEC 60950-1 named “Information technology equipment – Safety “

Noise standards

Test standards for noise used in this study will be ISO 7779 in operator position.

Test standards within Energy Star, TCO and other voluntary agreements are described under the “Voluntary agreement” headline.

1.7 Voluntary agreements

There are many different voluntary (and mandatory) environmental performance labels and declarations. The International Organization for Standardization (ISO) has identified three broad types of voluntary labels.

- Type I (ISO 14024) a voluntary, multiple criteria-based, third party program that awards a license that authorises the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations
- Type II (ISO 14021) informative environmental self-declaration claims
- Type III (ISO/TR 14025) environmental product declaration, EPD, voluntary programs that provide "quantified environmental data for a product with pre-set categories of parameters based on the ISO 14040 series of standards, but not excluding additional environmental information".

1.7.1 Type I Eco-labels

"Eco-labelling" is a voluntary method of environmental performance certification and labelling that is practised around the world. An "eco-label" is a label which identifies overall environmental preference of a product or service within a specific product/service category based on life cycle considerations. In contrast to "green" symbols or claim statements developed by manufacturers and service providers, an eco-label is awarded by an impartial third-party in relation to certain products or services that are independently determined to meet environmental leadership criteria. In Europe there are several national eco-labels, and other labelling schemes of which some are described below.

1.7.1.1. The European Union Eco-label, the Flower

http://europa.eu.int
www.eco-label.com

The European Union Eco-label, the Flower, was started in 1992 and can be found throughout the European Union as well as in Norway, Lichtenstein and Iceland. The European Union Eco-labelling Board (EUEB) develops ecological criteria for product groups in close collaboration with the Commission.

Today there are no computers or monitors labelled.

Desktops 2005/341/EC / Notebooks 2005/343/EC

Effective 2005**.**

The criterion regulates the energy consumption of Personal computers, Desktops/Notebooks in Sleep mode, Off mode, and the energy consumption of the external power supply when it is connected to the electricity supply but is not connected to the computer.

Table 1 Criteria for the European Union Eco-label, the Flower

Computer	Mode	Power Allowance
PC	Sleep	5W
	Off	2W
Note Book	Sleep	5W
	Off	2W

Power supply	Not connected to the computer	0.75W

Noise

Desktops
Measures according to ISO 7779 and declares in A-weighted sound power level (LWAd) according to ISO 9296 in dBel. (dB)
Noise levels must not exceed:
4.0 B(A) in the idle operating mode (equivalent to 40 dB(A))
4.5 B(A) when accessing a hard-disk drive (equivalent to 45 dB(A)).

Notebooks
Noise levels must not exceed:
Idling mode: 3.5 B (A).
When accessing a hard-disk drive: 4.0 B (A)

1.7.1.2 Energy star

For US: www.energystar.gov

For EU: www.eu-energystar.org

In 1992, US Environmental Protection Agency (EPA) introduced Energy Star as a voluntary labelling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. Personal computers and monitors are products within the scope of Energy star.

The European Union made an agreement with the US government to coordinate the energy-efficiency labelling programs for office equipment some years ago. Described is the version now effective (version 3.0) and also the new version (4.0) which will be effective from July 20 2007.

Computer Memorandum of Understanding (Version 3.0).

Effective in 1999. Applies to computers and integrated computer systems.

The ENERGY STAR Program Requirements for computers,

The Energy Star v. 3.0, criteria regulate the energy consumption in sleep mode in relation to the power consumption rated for the computer.

Table 2 Energy Star, version 3.0, criteria for computers.

Maximum Continuous Power Rating of Power Supply	**Watts in sleep mode**
$\leq$ 200W	$\leq$ 15W
> 200W $\leq$ 300W	$\leq$ 20W
> 300W $\leq$ 350W	$\leq$ 25W
> 350W $\leq$ 400W	$\leq$ 30W
> 400W	$\leq$ 35W

Of all labelling schemes, Energy Star has by far the best market coverage for computers. The European Energy Star programme today qualifies 268 PC models (Energy Star version 3.0).

ENERGY STAR Program Requirements for Computers: version 4.0

Effective July 20, 2007
Note: This is only a summary of the content, for the full text, www.eu-energystar.org

- Tier 1 Requirements –effective July 20, 2007
    - Power supply efficiency requirements
        - Internal Power Supply: 80% minimum efficiency at 20%, 50% and 100% of rated output and Power Factor $\geq$0.9 at 100% rated output.

  - External Power Supply: Must fulfil the ENERGY STAR requirements for External Power Supply (www.energystar.gov/powersupplies)

- Operational Mode Efficiency Requirements (for definitions and categories, se earlier in this report)

Table 3 Energy Star, version 4, criteria for computers.

Product Type	Tier 1 Requirements
Desktops, Integrated Computers, Desktop-Derived Servers and Gaming Consoles	Standby (Off Mode): <2.0 W Sleep Mode: $\leq$4.0 W Idle State: Category A: $\leq$ 50.0 W Category B: $\leq$ 65.0 W Category C: $\leq$ 95.0 W
Notebooks and Tablets	Standby (Off Mode): $\leq$ 1.0 W Sleep Mode : $\leq$ 1.7 W Idle State: Category A: $\leq$ 14.0 W Category B: $\leq$ 22.0 W
Capability adder for sleep and Standby	
Capability	Additional Power Allowance
Wake on LAN (WOL)	+ 0.7 W for Sleep + 0.7 W for Standby

- Power Management Requirements
  Products must be shipped with the display's Sleep mode set to activate within 15 min of user inactivity and Computer sleep mode to activate within 30 min of user inactivity

- All computers shall have the ability to enable and disable Wake on LAN

- User Information Requirement including information about the Power management, how to properly wake from sleep mode and about Energy Star

- Tier 2 Requirements –effective January 2009

  - To be decided

Energy Star Computer Test Method (version 4)

Test configuration

Power consumption of a computer shall be measured and tested from an AC source to the system.

Test conditions

Line Impedance: < 0.25 ohm
Total Harmonic Distortion: < 5%
Ambient Temperature: 25 deg. C +/- 3 deg. C
For products to be qualified in markets using 100V/120V input:

- Input AC Voltage[1]: 115 VAC RMS +/- 5V RMS
- Input AC Frequency[1]: 60 Hz +/- 3 Hz

For products to be qualified in markets using 230 V input:

- Input AC Voltage[1]: 230 VAC RMS +/- 5V RMS
- Input AC Frequency[1]: 50 Hz +/- 3 Hz

Testing equipment

A true RMS wattmeter with sufficient crest factor and frequency response, and a resolution of at least 0.1 W is needed.

Program Requirements for Computer Monitors Eligibility Criteria (version 4.1)

Effective in 2006. Applies to computers monitors.

The standard prescribes measurement of the monitor power consumption in Sleep, Off and Active mode. In Active mode particular luminance adjustments are stipulated.

Table 4 Energy Star, version 4.1, Energy criteria for computer monitors.

Sleep	2W
Off	1W
Active mode	X < 1 mega pixel, then Y = 23; if X > 1 mega pixel, then Y = 28X. Y is expressed in watts and rounded up to the nearest whole number and X is the number of mega pixels in decimal form X= Mega pixels Y= Allowed power consumption

Test Conditions:

Table 5 Energy Star, version 4.1, test conditions for computer monitors.

Supply Voltage*:	North America: Europe: Australia/New Zealand: Japan:	115 (± 1%) Volts AC, 60 Hz (± 1%) 230 (± 1%) Volts AC, 50 Hz (± 1%) 230 (± 1%) Volts AC, 50 Hz (± 1%) 100 (± 1%) Volts AC, 50 Hz (± 1%)/60 Hz (± 1%)
Total Harmonic Distortion (Voltage):	< 2% THD	
Ambient Temperature:	20°C ± 5°C	
Relative Humidity:	30 – 80 %	
Line Impedance:	< 0.25 ohm	

The measurements shall be performed with a RMS power meter

The RMS power meter shall have a crest factor of at least five.

The labelling scheme has had and has a very important impact in the reduction of power consumption on computer monitors.

1.7.1.3 TCO Development, TCO label

www.tcodevelopment.com

The TCO label is global – the certificate has no geographical limitations and the label is present in markets in many parts of the world with the strongest base in the northern part of Europe. The TCO labelling started in 1992 and does not only cover environmental issues, but also addresses other issues regarding the work environment, such as image quality, visual and work load ergonomics, noise, electromagnetic- and chemical emissions.

Today about 50 % of all computer displays in the world are TCO-labelled (about 3500 models). About 20 computers are TCO-labelled.

Standards: *TCO'05 Desktop computers, version.1.0 /*
TCO'05 Notebook computers, version 2.0
Effective 2005.

The criteria regulate the energy consumption of Personal computers, Desktops/Notebooks in Sleep mode and Off mode.

Table 6 Energy criteria for TCO 05, computers.

Computer	Mode	Power Allowance
PC	Sleep	5W
	Off	2W
Notebook	Sleep	4W
	Off	2W

Noise

Measures according to ISO 7779 and declares in A-weighted sound power level (LWAd) according to ISO 9296 in Bel. (B)

Noise levels must not exceed:

Operating mode: 3.9 B
Idling mode: 3.5B
If the product does not emit prominent discrete tones according to procedures specified in ECMA 74 Annex D a higher declared A-weighted sound power level (LWAd) is accepted butshall not exceed:
Operating mode: 4.2B
Idling mode: 3.8B

If noise emission measurement is carried out on one appliance only, the declared sound power level LWAd" shall be LWA + 0.3 B.

Standard: *TCO'03 Displays, Flat Panel Displays Ver 3.0*
Effective 2005-10-19

The standard prescribes measurement of the monitor power consumption in Sleep, Off and Active mode. In Active mode particular luminance adjustments are stipulated.

The power consumption criteria and the measurement methods is harmonised with the criteria in Energy Stars, Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1) Tier 2.

The standard and its predecessors have had a decisive impact on the power consumption for computer monitors.

Standard: *TCO'03 Displays, CRT Displays Ver. 3.0*

The standard prescribes measurement of the monitor's power consumption in Sleep and Off mode.

Table 7 Energy criteria for TCO 03, monitors.

Sleep mode	≤ 4W
Off mode	≤3 W

Test conditions
AC mains voltage* 230 VAC RMS, tolerance ± 1 %
AC mains frequency* 50 Hz, tolerance ± 0.5 Hz
Line impedance 0.25 Ω
Total harmonic distortion < 2%
Test room temperature 23±3 $_{o}$C [1]
Humidity 20-75 % RH (non-condensing) [2]

Refresh rate 85 Hz [3]

---

* – or other voltage and frequency combination specified by the client based the market in which the VDU will be sold.

The measurements shall be performed with a RMS power meter
The RMS power meter shall have a crest factor of at least five.

1.7.1.4 Nordic Eco labelling: The Swan

www.svanen.nu
The Swan is the official Nordic eco-label, introduced by the Nordic Council of Ministers in 1989. Today about 5 computer displays and 24 computers are labelled with the Swan.

Standard: *Personal computers Ver. 4.1*
Effective 2005.

The criterion regulates the energy consumption of Personal computers, Desktops/Notebooks in Sleep mode, Off mode, and the energy consumption of the external power supply when it is connected to the electricity supply but is not connected to the computer.

Table 8 Energy criteria for the Swan, personal computers.

Computer	Mode	Power Allowance
PC	Sleep	5W
	Off	2W
Note Book	Sleep	5W
	Off	2W

Power supply	Not connected to the computer	0.75W

Noise

Measures according to ISO 7779 and declares in A-weighted sound power level (LWAd) according to ISO 9296 in Bel. (B)

Noise levels must not exceed:

Desktop computers,: Operating mode: 5,0 B (A), Idling mode: 4,5 B (A)
Deskside computers, Operating mode: 5,3 B (A) Idling mode: 4,8 B (A)
Portable computers, Operating mode: 4,5 B (A)) Idling mode: 4,0 B (A)

1.7.1.5 The Blue Angel

www.blauer-engel.de
The Blue Angel was created in 1977 on the initiative of the German Federal Minister of the Interior and approved by the Ministers of the Environment of the

national government and the federal states. Today about 7 computer displays and 63 computers are labelled with the Blue Angel.

Standards: *Computers RAL-UZ-78*
Effective 2006.

The criterion regulates the energy consumption of Personal computers, Desktops/Notebooks in Sleep mode, Off mode, and the energy consumption of the external power supply when it is connected to the electricity supply but is not connected to the computer.

Table 9 Energy criteria for the Blue Angel.

Computer	**Mode**	**Power Allowance**
PC	ON (ACPI S3)	<4,5 W
	Off without wake up	< 2,5 W
	Off with wake up function	< 3,5 W
Note Book	ON (ACPI S3)	<3,5 W
	Off	< 2 W
Monitors	ON <1 megapixels	23 W
	On >= 1 megapixels	28*pixels
	Sleep	2 W
	Off	1 W

Noise

Measures according to ISO 7779 and declares in A-weighted sound power level (LWAd) according to ISO 9296 in dBel. (dB)

Noise levels must not exceed:

Idle mode max 44 dB(A)
If noise emission measurement is carried out on one appliance only, the declared sound power level LWAd" shall be LWA +3dB.

1.7.1.6 Group for Energy Efficient Appliances

http://www.gealabel.org

Standard: *Product Sheet, Personal Computers (system units)*
Reference: IT01-280601
Effective 2006.

The criterion regulates the energy consumption of Personal computers, Desktops/Notebooks in Sleep mode, Off mode and On mode. External power supply, if any, shall comply with EU "Code of Conduct on Energy Efficiency of External Power Supplies" version 2, phase 2

Table 10 Energy criteria for the Group for energy-efficient appliances.

Computer	Mode	Power Allowance
PC	Sleep	5W
	Off	2W
	On (Idle)	70W

Power supply	Not connected to the computer	0.3 – 0.5W

1.7.1.7 The Top Runner System, Japan

http://www.eccj.or.jp/top_runner/index.html

The Top Runner System uses, as a base value, the value of the product with the highest energy consumption efficiency on the market at the time of the standard establishment process and sets standard values by considering potential technological improvements added as efficiency improvements. The target standard values are extremely high. For achievement evaluation, manufacturers can achieve target values by exceeding target values by weighted average values using shipment volume, the same as the average standard value system.

Under this system, designated machinery and equipment products are required to achieve a weighted average value by the target fiscal year right now year 2007, using each manufacturer's shipment volumes by category. Under this method, if demand is high for a product whose manufacturer emphasises other functionalities over energy consumption efficiency, the manufacturer can ship the equipment even if the energy consumption efficiency is lower than the target value. That is, the manufacturer can achieve the target value on an average basis by shipping a product with higher efficiency in the same category. The system functions well to facilitate manufacturers' voluntary activities.

Top runner Computer classifications

The top runner classification method gives several different classes based on:

1. Classifications based on product characteristics
Computers are largely classified in terms of the nature of their usage and necessary functions into server-side computers (mainframe computers, mid-range computers, etc.) and client-side computers (workstations, desktop PCs, etc.). Client-side computers are further divided into desktop computers (non-battery-driven) and notebook PCs (battery-driven).
2. Classification based on performance characteristics such as number of I/O signal transmission paths (I/O) and memory size.

Top runner Energy consumption efficiency measurement method

Energy consumption efficiency is calculated by the following formula.
$\mathbf{E = [(W_1 + W_2)/2] / Q}$

In this formula, E, W_1, W_2 and Q represent the following values.
E: Energy consumption efficiency (unit: watts/million calculations)
$(W_1+W_2)/2$: Power consumption (unit: watts)

W_1: Power consumption in idle state (unit: watts)

The power consumption of the idle state (hereinafter "idle state") is when operation is possible without resetting the initial programs and in the states before operating in low power mode such as standby mode and suspended mode in accordance with the ACPI standards.

W_2: Power consumption in low power mode (unit: watts)

The power consumption of low power mode is the low power mode of standby mode and suspended mode in ACPI standards (however, limited to states in which program and data are store in the main memory). Concerning server-side computers and client-side computers that do not have low power modes, the value of W_1 is used for W_2.

Q: Composite theoretical performance (CTP) (unit: millions of calculations)

W_1 is expressed in watt units for values measured by the method below.

1 Ambient temperature between 16°C and 32°C.

2 Power supply voltage in ±10% specified input voltage. However, for items with specified input voltage of 100 volts, it is ±10% of 100 volts

3 Power supply frequency at standard frequency

4 Without losing the computer's basic functionality, measurements are done with the maximum configuration on a scope that removes I/O control equipment, communications control equipment, HDDs, etc. that can be disconnected from the computer. For items to which the number of processors can be expanded, measurements shall be done with the minimum configuration of processors. For items other than battery-driven types among client-side computers, measurements can be done with the power supply to the graphic display turned off.

W_2 is expressed in watt units for values measured by the method below.

1 Ambient temperature shall be 16 to 32°C

2 The power supply voltage shall be within the range of the rated input voltage ±10%. If a computer has a rated input voltage of 100 volts, the power voltage shall be within the range of 100 volts ±10%

3 The power supply frequency shall be the rated frequency

4 The measurement shall be made using a system configuration which retains a maximum of basic computer functions while the I/O control unit, communication control unit, magnetic disk drive unit and other removable units disconnected from the computer. However, if the computer is of a type that allows more processors to be installed, the measurement shall be performed using the number of processors required for a minimum configuration.

HDDs (Hard Disk Drives)

Top runner does also have energy consumption efficiency targets and measuring methods for HDD divided in several classes, due to disk size and number of discs.

1.7.1.8 Comparison of criteria for Desktops within different eco-labelling systems

This information is just an overview and is not complete. For the detailed information please consult the criteria documents (available at the websites of the different eco-labels).

The comparison is made between:

- TCO'05 Desktops, Version 1.0 2005-06-29 www.tcodevelopment.com. International labelling
- Swan labelling of Personal computers, Version 4.1 June 2005 – 18 June 2008 www.svanen.nu. Nordic labelling
- Blue Angel. *Computers RAL-UZ-78* Effective 2006. www.blauer-engel.de. German labelling
- EU-flower. Ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to personal computers (2005/341/EC), 11 April 2005 www.eco-label.com. European labelling
- ENERGY STAR Program Requirements for Computers: version 4.0 (and Energy Star. Computer Memorandum of Understanding (Version 3.0). Effective in 1999).

Table 11 Comparison of the labelling criteria for desktops.

Criteria for Desktops	**TCO'05**	**The Swan**	**Blue angel**	**EU-flower**	**Energy Star**
Visual Ergonomics	X				
Work load ergonomics	X				
Electromagnetic Emissions	X	X[1]	X[1]	X[1]	
Acoustic Noise	X	X	X	X	
Energy [2]	X	X	X	X	X
Ecology	X	X	X	X	

[1] The requirements in TCO'05 are stricter.

[2] See separate comparison.

Table 12 Comparison of the labelling criteria for desktops.

Criteria for Desktops	TCO'05	The Swan	Blue angel	EU-flower
Ecology				
Environmental Responsibility				
Company's environmental responsibility	X	X		
Environmental hazards				
Mercury, cadmium, and lead	X	X	X	X
Flame retardants	X	X	X	X
Chlorinated plastics	X	X	X	
Preparation for Recycling				
Material coding of plastics	X	X	X	X
Variety of plastics	X	X	X	X
Metallization of plastics	X	X	X	X
Material recovery of plastics and metals		X	X	X
Design for recycling - Mercury lamps	X	X	X	X
Easy to dismantle		X	X	X
Recycling information for customers	X	X	X	X
Guarantee and spare parts				
Guarantee		X	X	
Supply of spare parts		X	X	
Upgradebility/performance expansion		X	X	X
Packaging				
Requirements regarding packaging materials			X	X

Table 13 Comparison of the eco-labelling criteria for desktops.

Energy criteria for Desktops	**The Swan** Jun 2005	**EU-Flower** April 2005	**TCO´05** Jul 2005	**GEEA*** 2006 ?	**Blue Angel** 2006	**Energy Star** 2007 (1999)
Sleep	4W	4W	5W	5W	4,5W	4.0 W (15-35*)
Off	2W	2W	2W	2W	2,5W	2.0 W
On idle	-	-	-	70 W	-	50-95
Labelled products	20	-	- (16 TCO´99)	? latest update 2002	60	(288)

1.7.1.8 Comparison of criteria for Notebooks within different eco-labelling systems

This information is just an overview and is not complete. For the detailed information please consult the criteria documents (available at the websites of the different eco-labels).

The comparison is made between:

- TCO'05 Notebooks, Version 2.0 2005-09-21 www.tcodevelopment.com. International labelling
- Swan labelling of Personal computers, Version 4.1 June 2005 – 18 June 2008 www.svanen.nu. Nordic labelling
- Blue Angel. *Computers RAL-UZ-78* Effective 2006. www.blauer-engel.de. German labelling
- EU-flower. Ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to portable computers (2005/343/EC),
  11 April 2005 www.eco-label.com. European labelling.
- ENERGY STAR Program Requirements for Computers: version 4.0 (and Energy Star. Computer Memorandum of Understanding (Version 3.0). Effective in 1999).

Table 14 Comparison of labelling criteria for notebooks.

Criteria for Notebooks	TCO'05	The Swan	Blue angel	EU-flower	Energy Star
Visual Ergonomics	X	X[1]	X[1]		
Work load ergonomics	X				
Electromagnetic Emissions	X	X[1]	X[1]	X[1]	
Acoustic Noise	X	X	X	X	
Energy [2]	X	X	X	X	X
Ecology	X	X	X	X	

[1] The requirements in TCO'05 are stricter.
[2] See separate comparison.

Table 15 Comparison of labelling criteria for notebooks.

Criteria for Notebooks	TCO'05	The Swan	Blue angel	EU-flower
Ecology				
Environmental Responsibility				
Company's environmental responsibility	X	X		
Environmental hazards				
Mercury, cadmium, and lead	X	X	X	X
Flame retardants	X	X	X	X
Chlorinated plastics	X	X	X	
Preparation for Recycling				
Material coding of plastics	X	X	X	X
Variety of plastics	X	X	X	X
Material recovery of plastics and metals		X	X	X
Mercury lamps	X	X	X	X
Easy to dismantle		X	X	X
Recycling information for customers	X	X	X	X
Guarantee and spare parts				
Guarantee		X	X	
Supply of spare parts		X	X	
Upgradebility/performance expansion		X	X	X
Packaging				
Requirements regarding packaging materials			X	X

Table 16 Comparison of energy criteria for notebooks.

Energy Criteria for Laptops	**Energy Star** July 2007 (1999)	**The Swan** Jun 2005	**EU-flower** Apr 2005	**TCO`05** Jul 2005	**GEEA** 2006?	**Blue Angel** 2006
Sleep	≤ 1.7W (15-35)	3W	3W	4W	5W	3,5W
Off	≤ 1W	2W	2W	2W	2W	2W
Idle	≤ 14-22W					
Power supply	84%	0.75W	0.75W	-	-	-
Labelled products	0 (352)	-	-	- (4 TCO´99)	-	-

1.7.1.9 Comparison of criteria for Monitors within different eco-labelling systems

This information is just an overview and is not complete. For the detailed information please consult the criteria documents (available at the websites of the different eco-labels).

The comparison is made between:

- TCO’03 Displays FPD/CRT, Version 3.0 2005-10-19 www.tcodevelopment.com. International labelling
- Swan labelling of Personal computers, Version 4.1 10 June 2005 – 18 June 2008 www.svanen.nu. Nordic labelling
- Blue Angel. *Computers RAL-UZ-78* Effective 2006. www.blauer-engel.de. German labelling
- EU-flower. Ecological criteria and the related assessment and verification requirements for the award of the Community eco-label to personal computers (2005/341/EC), 11 April 2005 www.eco-label.com. European labelling.
- ENERGY STAR Program Requirements for Computer Monitors eligibility criteria v 4.1

Table 17 Comparison of labelling criteria for Monitors.

Criteria for Monitors	TCO'03	The Swan	Blue angel	EU-flower	Energy Star
Visual Ergonomics	X	X[1]	X[1]		
Work load ergonomics	X				
Emissions	X	X[1]	X[1]	X[1]	
Energy [2]	X	X	X	X	X
Ecology	X	X	X	X	

[1] The requirements in TCO'03 are stricter.
[2] See separate comparison.

Table 18 Comparison of labelling criteria for Monitors.

Criteria for Monitors	TCO'03	The Swan	Blue angel	EU-flower
Ecology				
Environmental Responsibility				
Company's environmental responsibility	X	X		
Environmental hazards				
Mercury, cadmium, and lead	X	X	X	X
Flame retardants	X	X	X	X
Chlorinated plastics	X	X	X	
Preparation for Recycling				
Material coding of plastics	X	X	X	X
Variety of plastics	X	X	X	X
Metallization of plastics	X	X	X	X
Material recovery of plastics and metals		X	X	X
Design for recycling - Mercury lamps	X	X	X	X
Easy to dismantle		X	X	X
Recycling information for customers	X	X	X	X
Guarantee and spare parts				
Guarantee		X	X	
Supply of spare parts		X	X	
Packaging				
Requirements regarding packaging materials			X	X

Table 19 Comparison of labelling energy criteria for Monitors.

Energy criteria for Monitors	**Energy Star** Jan 2006	**GEEA** 2006	**TCO´03** Jan 2006	**The Swan** Jun 2005	**EU-flower** Apr 2005	**Blue Angel** 2006
Sleep	2W	* With USB 2.3 W	*	*	*	*
Off	1W	*	*	*	*	*
Active mode	(1)	*	*	*	*	*
Labelled products	464	?	717 (3000 TCO´99)	5	-	3

(1) X < 1 megapixel, then Y = 23; if X > 1 megapixel, then Y = 28X. Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form
X= Mega pixels
Y= Allowed power consumption

** Same requirement as Energy Star*

1.7.2 Type II Self-declaration

1.7.2.1 ECMA 370 THE ECO DECLARATION-TED

www.ecma-international.org

A self declaration which is a harmonisation between The Ecma Technical Report TR/70 and IT-Ecodeclaration which was launched in 1996 by IT-företagen in Sweden. It is a self declaration to be used when selling products to environmentally aware customers. There are two parts in the declaration:

The Company environmental profile covers

- Recycling system participations
- Environmental policy and environmental management systems

Environmental product attributes covers

- Hazardous substances
- Batteries
- Safety and EMC
- Consumable materials
- Packaging materials
- Treatment information

- Environmental conscious design (such as disassembly, recycling, product life time)
- Energy consumption
- Emissions
- Ergonomics
- Documentation
- **Note:** ECMA do also have a working group working on computer performance and energy consumption in order to make a standard on energy efficiency, perhaps for use within the EuP. It might become important to the outcome of the EuP regulations for products within the scope of this study. But the ECMA working group have recently started, and aim at finishing their work late 2007, and their results will therefore not be a part of this preparatory study**.** [ECMA 2006].

1.7.2.2 The IT-Ecodeclaration

www.itecodeclaration.org

Since the harmonisation with ECMA there is a possibility for manufacturers to have their eco-declaration (ECMA 370) verified by IT-Företagen.

1.7.2.3 EPEAT

www.epeat.net

EPEAT, the "Electronic Product Environmental Assessment Tool," is a procurement tool designed to help institutional purchasers in the public and private sectors in the USA to evaluate, compare and select desktop computers, laptops and monitors based on their environmental attributes. The system will be available to manufacturers for registering their products in late May of 2006, and the product registry will be viewable and searchable by purchasers in June of 2006.

EPEAT is a system in which manufacturers declare their products' conformance to a comprehensive set of environmental criteria in eight environmental performance categories:

- Reduction/Elimination of Environmentally Sensitive Materials
- Material Selection
- Design for End of Life
- Product Longevity/ Life Cycle Extension
- Energy Conservation
- End of Life Management
- Corporate Performance
- Packaging

EPEAT evaluates electronic products according to three tiers of environmental performance – Bronze, Silver and Gold. To achieve the bronze level, the product shall conform to all of the 23 required environmental criteria in IEEE 1680 (Standard for Environmental Assessment of Personal Computer Products, Including Laptop Personal Computers, Desktop Personal Computers, and Personal Computer Monitors). To achieve the silver level, the product shall conform to all of the required criteria plus at least 50% of the 28 optional criteria, and to achieve the gold level the product shall conform to all the required criteria and at least 75% of the optional criteria.

1.7.3 Type III declarations

1.7.3.1 The EPD®system

www.environdec.com

An environmental product declaration, EPD, is defined as "quantified environmental data for a product with pre-set categories of parameters based on the ISO 14040 series of standards on life cycle assessment, but not excluding additional environmental information". The EPD® system is a programme for Type III environmental declarations with an international applicability. EPDs, which are always based on a life cycle assessment, are primarily intended for use in business-to-business communication, but their use in business-to-consumer communication is not precluded.

The EPD®system is operated by an independent so-called programme operator, the Swedish Environmental Management Council, SEMC. SEMC is responsible for providing general guidelines which describe the overall aim, methodological structure and elements of the EPD®system.

The EPD®system is one of other available EPD programmes, however being the only programme at present aiming at an international applicability.

There is today one make of LCD-modules but no personal computer with an EPD registered in the EPD®system.

1.7.4 Test standards and voluntary agreements and this study

There are several voluntary initiatives working on improvement of the environmental performance of the products within the scope of this study. Some of them are of more importance than others. For this study, the most important voluntary initiatives are Energy Star (for Computers and Monitors) and the TCO labelling schemes (for Monitors), since they are most widely used, and also since they are regularly updated with more tight requirements to keep stimulating improved environmental performance.

The results of energy consumption measurements are totally dependent on how the different testing standards have chosen to set up the unit under test, especially in the Active/Idle mode. It is therefore often very difficult to compare results from tests being performed according to different testing standards. Regarding test standards within this study, the ones used by most of the labelling schemes and initiatives for computers and monitors will be used. Energy consumption will be assessed in off, sleep and on (idle) modes according to the coming *ENERGY STAR Computer Test Method (Version 4.0), effective July 19, 2007* for computers and the *ENERGY STAR Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1)* for monitors. *ISO 7779* will be used for noise.

1.8 Existing legislation

The main objective with describing the existing legislation is to guarantee that suggestions and proposed activities follow the existing legislation. Since the legal documents are often very large, attempts to summarize the most important parts of them are made here. To get the full details, please look into the full documents.

1.8.1 Legislation and Agreements at EU-Level

1.8.1.1 WEEE Directive for Waste of Electric and Electronic Equipment **2002/96/EEC (february 2003)**

http://ec.europa.eu/environment/waste/weee_index.htm

An important conclusion from the 30 May workshop was that declarations prepared for complying with the WEEE-directive are very suitable as bill of materials. In other words, it will be relatively easy for industry to supply the LCA data needed thanks to WEEE.

Product design

Member States shall encourage the design and production of electrical and electronic equipment which take into account and facilitate dismantling and recovery, in particular the reuse and recycling of WEEE, their components and materials. In this context, Member States shall take appropriate measures so that producers do not prevent, through specific design features or manufacturing processes, WEEE from being reused, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements.

Separate collection

1 Member States shall adopt appropriate measures in order to minimise the disposal of WEEE as unsorted municipal waste and to achieve a high level of separate collection of WEEE

2 For WEEE from private households, Member States shall ensure that by the 13 August 2005:

(a) systems are set up allowing final holders and distributors to return such waste at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities, taking into account in particular the population density;

(b) when supplying a new product, distributors shall be responsible for ensuring that such waste can be returned to the distributor at least free of charge on a one-to-one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment. Member States may depart from this provision provided they ensure that returning the WEEE is not thereby made more difficult for the final holder and provided that these systems remain free of charge for the final holder. Member States making use of this provision shall inform the Commission thereof;

(c) without prejudice to the provisions of (a) and (b), producers are allowed to set up and operate individual and/or collective take-back systems for WEEE from private households provided that these are in line with the objectives of this Directive;

(d) having regard to national and Community health and safety standards, WEEE that presents a health and safety risk to personnel because of contamination may be refused for return under (a) and (b). Member States shall make specific arrangements for such WEEE.

Implementation of WEEE

The implementation of WEEE directive in the member states is ongoing.

1.8.1.2 RoHs Restriction of Hazardous substances

The RoHs directive, 2002/95/EC, dictates that Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). National measures restricting or prohibiting the use of these substances in electrical and electronic equipment which were adopted in line with Community legislation before the adoption of this Directive may be maintained until 1 July 2006.

1.8.1.3 EMC

The EMC directive, 89/336/EEC (to be replaced by 2004/108/EC) set restrictions on the emission of electromagnetic radiation and on the immunity against electromagnetic radiation for electronic products. Countries outside the EU have similar regulations although the detailed requirements differ. In some countries there are, for instance, no restrictions on immunity.

In addition to the general EMC directive more detailed standards exists for certain products such as computers.

From the perspective of this study the EMC directive is not critical.

1.8.2 Legislation at Member State level

Since legislation at member state level follow the European directives, there appears to be no other particular legislation at member state with relevance for this study. As an example, the Swedish legislation is described below. The main differences between the European countries are the time schedules for implementing the European directives.

In Sweden *Förordning om förbud mm i vissa fall i samband med hantering, införsel och utförsel av kemiska produkter*, SFS 1998:944, contains the restrictions from the RoHS directive for use of cadmium, mercury, lead, chromium and some other chemicals in electric and electronic products. The WEEE directive is mainly implemented in *Förordningen om producentansvar för elektriska och elektroniska produkter*, SFS 2005:209. While SFS 1998:944 and SFS 2005:209, concerns the computer manufacturer, *Avfallsförordning*, SFS 2001:1063, stipulates that the computer user should separate computer waste from the normal waste stream.

Miljöbalken, the environmental framework law in Sweden, stipulates in the 5th general principle about Housekeeping and materials circulation that everybody should "5 §. Economize with resources and energy and use renewable energy as a first priority." This principle has however not yet been tried in the context of manufacturing and use of personal computers.

In short, Sweden has implemented the RoHs and WEEE directives and has, in practice, no separate national restrictions regarding the manufacturing and use of computers.

The Danish governmental institutions are obliged to purchase energy efficient appliances due to "circular on improving energy efficiency in Danish state institutions" from April 2005.

1.8.3 Third Country Legislation

The European legislation WEEE and RoHs is spreading to countries outside the EU. In most cases the national legislation is similar to the European, but there are some differences. The most important ones are described below.

China

The Chineese RoHs, called "Administrative Measures on the Control of Pollution Caused by Electronic Information Products" will start to take effect from the 1st January 2007. It is very similar to EU RoHs regarding substances. The difference is that all products have to be tested in an authorised laboratory before they can be sold in China. The legislation is not covering export from China.

California

California follows RoHs strictly. An exemption must be decided by EU, which the industry find difficult. It also sets targets for recyclability and improvement targets for recycling.

Korea

Korea follows RoHs and WEEE, with the difference that the Korean law covers both electronics and automotives in the same legislation.

1.8.4 Existing legislation and this study

The most important legislations according to our analysis are the RoHS and the WEEE directives. One important reason is that there might be conflicts between energy consumption and chemical content and/or end-of-life treatment. The VHK-methodology also prescribes a “past WEEE and RoHs-situation” for the calculations in the study. Other legislation might have an impact on this study regarding options for improvement. It is essential that the suggestions either follows the existing legislation, or point out which changes in legislation might be needed to reach the improvements suggested.

1.9 References

- MEEUP Methodology Report. Final Report. Methodology Study Eco-design of Energy-using Products. 28.11.2005. VHK for European Commission.Available at http://www.vhk.nl/
- INVITATION TO TENDER No. TREN/D1/40-2005
- ENERGY STAR® Program Requirements for Computers DRAFT 3. Version 4.0
- ENERGY STAR® Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1)
- EPIC-ICT (2006) Development of Environmental Performance Indicators for ICT Products on the example of Personal Computers. Draft January 2006. "Data needs and data collection, Generic Modules, Environmental impacts, Impact assessment and weighting, Environmental interpretation and evaluation"
- Fujitsu FMV Lifebook. Product Environmental Aspects Declaration. Ecoleaf 2003. http://www.jemai.or.jp/english/ecoleaf/
- Atlantic Consulting and IPU. LCA Study (Version 1.2), EU Ecolables for Personal Computers, March 1998.
- Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. May 2006 Technical Report EUR 22284 EN
- WEEE Directive for Waste of Electric and Electronic Equipment 2002/96/EEC (february 2003)
- RoHs Restriction of Hazardous substances 2002/95/EC
- ECMA 370 THE ECO DECLARATION-TED www.ecma-international.org
- Telephone call with Silvio Weeren ECMA September 2006
- *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 they do cover the main players for both computers and monitors, and also covering companies from Europe, The USA and Asia. The number of respondents to the questionnaire was 16
- "circular on improving energy efficiency in Danish state institutions" from April 2005. www.elsparefornden.dk/publikationer/publications-in-english/circular-on-improving-energy-efficiency

2 Economic and market analysis

Introduction

The objective of this part of the study and the report is to make an economic and market analysis to use within the subsequent tasks of this 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.

The main sources for information have been Eurostat, EITO and the stakeholder survey performed during 2006.

2.1 Generic Economic Data

2.1.1 Task and Procedure

To determine the volumes and values of the product categories " personal computers and monitors" within the total of EU industry and trade policy, the following generic economic data will be researched:

- EU-production
- Extra-EU trade
- Intra-EU trade
- Apparent consumption.

To present some indication of the installed base of equipment, indicative data on medium expected lifetime for the different types of equipment covered in the report are taken from the answers from industry, supplied in the survey[2006].

To make the data coherent with official EU data, the statistical information is derived from Eurostat, the official statistical office of EU.

Since the data from Eurostat has some limitations we will include, later in the report, trade-data given by the industry, as a comparison.

The most appropriate dataset in Eurostat, for our purposes, is the dataset PRODCOM, which gives production and trade data for a very large number of product-groups (more than 7000).

The following PRODCOM codes are applicable to the investigated product groups.

Table 20 PRODCOM classification applicable to PC, Laptops and Desktops

PRODCOM-Code	Code Description
30021200	Laptop PCs and palm-top organisers
30021300	Desk top PCs
30021400	Digital data processing mach//systems
32302045	Colour video monitors wit//de-ray tube
32302049	Flat panel video monitor//de-ray tube)
32302083	Black and white or other monochrome monitors

Apart from PRODCOM, Eurostat also provides a dataset on EU-25 trade statistics, (Comext). This dataset, which does not contain any production data but purely trade data, is based on CN codes (Combined Nomenclature). The relations between PRODCOM codes and CN codes for relevant equipment are presented in the table below. The use of CN codes for computers and monitors is highly complicated due to the fact that there have been numerous changes in the CN coding scheme during the years of interest. The table below shows these changes to the best of our ability.

Table 21 PRODCOM classifications and corresponding CN-codes applicable to PC, Laptops and Desktops

PRODCOM-Code	Code Description	Corresponding CN-code	Code Description	From	To
30021200	Laptop PCs and palm	84713000		01/01/1996	31/12/1997
30021200	Laptop PCs and palm	84713010	Laptop computers, notebooks whether or not incorporating multi media kit	01/01/1998	31/12/1999
30021200	Laptop PCs and palm	84713091	84713090 Other, portable digital automatic data processing machines, weighing not more than 10 kg Other digital automatic data processing machines, comprising in the same housing at least a central processing unit, a keyboard and a display.	01/01/1998	31/12/1999
30021200	Laptop PCs and palm	84713099		01/01/1998	31/12/1999
30021200	Laptop PCs and palm	84713000		01/01/2000	31/12/2005
30021300	Desk top PCs	84714110	Other digital automatic data processing machines, comprising in the same housing at least a central processing unit, a keyboard and a display (main frame)	01/01/1996	31/12/2005
30021300	Desk top PCs	84714130		01/01/1998	31/12/1999
30021300	Desk top PCs	84714190	Other digital authomatic data processing machines (other than main frame)	01/01/1996	31/12/1997
30021300	Desk top PCs	84714190		01/01/2000	31/12/2005
30021300	Desk top PCs	84714191		01/01/1998	31/12/1999
30021300	Desk top PCs	84714199		01/01/1998	31/12/1999
30021400	Digital automatic data processing machines presented in the form of systems	84714910	Other digital automatic data processing machines, presented in the form of systems, Pcs (personal computers) whether or not incorporating multi media kits	01/01/1996	31/12/2005
30021400	Digital automatic data processing machines presented in the form of systems	84714930		01/01/1998	31/12/1999
30021400	Digital automatic data processing machines presented in the form of systems	84714990	Other digital automatic data processing machines, presented in the form of systems	01/01/1996	31/12/1997
30021400	Digital automatic data processing machines presented in the form of systems	84714990		01/01/2000	31/12/2005

PRODCOM-Code	Code Description	Corresponding CN-code	Code Description	From	To
30021400	Digital automatic data processing machines presented in the form of systems	84714991		01/01/1998	31/12/1999
30021400	Digital automatic data processing machines presented in the form of systems	84714999		01/01/1998	31/12/1999
32302045	Colour video monitors with cathode-ray tube	85281031		01/01/1993	31/12/1995
32302045	Colour video monitors with cathode	85281041		01/01/1993	31/12/1995
32302045	Colour video monitors with cathode	85281043		01/01/1993	31/12/1995
32302049	Flat panel video monitor, LCD or plasma, etc., without tuner (colour video monitors) (excl. with cathode-ray tube)	85281049		01/01/1993	31/12/1995
32302083	Black and white or other monochrome video monitors	85282020		01/01/1993	31/12/1995

Since both the PRODCOM codes and the CN-coding scheme have evolved over time, neither of the datasets are distinctive and clear enough to provide ideal data for this investigation. Apart from changes in coding over the years, the product definitions are in several cases dubious in the sense that it is not clear what parts of equipment are included. This can later be seen especially in the case of Desktops, where it is not clearly stated whether a monitor is included or not, and if it is included, it is not indicated what type of monitor.

The quality of data seems to be very dependant on the distinctness of the coding, as can be seen later in the report. The data on Laptops, which is probably the most distinct code, seem to be much more "reliable" (no disruptive changes) as compared to the data on Desktops, for which the definition is less obvious. On the other hand, the code for laptops also includes palmtops, which are to be left out of the study, thus making the data from Eurostat quite inappropriate for the study. This has been solved by using data from other sources, EITO and answers from an industry survey, to compile a more correct picture of the sales figures on laptops.

2.1.2 Results

2.1.2.1 Production of Desktops, laptops and monitors in EU-25

The following Tables, 22 and 23 contain the data provided by PRODCOM for domestic production in 2004. The data have lots of empty spaces, which are either due to data not reported by the country or, due to confidentiality reasons. When data are incomplete, Eurostat does not publish an EU summery.

The Eurostat reasons for missing data are explained in Williams [2003] by the following paragraphs:

Availability of data

There are two reasons why expected data might not be found in Europroms:

The data is confidential. If only a small number of enterprises produce a product in the reporting country, there is a risk that information regarding an individual enterprise might be revealed. If the enterprise does not agree to this the reporting country declares the production figures confidential. They are transmitted to Eurostat but not published.

However if several countries declare their production for a heading to be confidential, an EU total can be published because the data for an individual country cannot be inferred.

The data is missing. There are a number of reasons why data might be missing: the reporting country does not survey the heading; the reporting country has reason to doubt the accuracy of the data and suppresses it; or the reporting country uses the wrong volume unit or the wrong production type, which means that the data is not comparable with other countries and is suppressed by Eurostat.

If data is missing for one or more Member States the corresponding EU total cannot be calculated and is also marked as missing.

Europroms stands for the combined data from PRODCOM and Comext, published in PRODCOM. In the continued text, PRODCOM will be stated as the source also for Europroms.

In the tables produced by PRODCOM, countries negotiating for EU membership are also included. Their values are not included in the EU25 totals.

Table 22 Personal computers EU25, domestic production in 2004 (PRODCOM statistics)

2004	Laptop PCs and palm-top organisers		Desktop PCs		Digital data processing systems	
	VOLUME	VALUE	VOLUME	VALUE	VOLUME	VALUE
	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)
France	407	392			47	
Netherlands					10	52
Germany	3332	2642	627	383	2517	1497
Italy	36	37	66	104	12	14
United Kingdom	104	135		174	665	536
Ireland						
Denmark	0	0	2	2	3	8
Greece						
Portugal			99	63		
Spain	94	99	48	30	257	140
Belgium			98	46		
Luxemburg						
Iceland						
Norway						
Sweden					25	44
Finland	0	1	40	45	2	2
Austria	262	221				
Malta						
Estonia			61	28		
Latvia			7	3		
Lituania			37	24		
Poland	67	37	176	42		
Czech Republic						
Slovakia						
Hungary					3436	1031
Romania			72	35		0
Bulgaria				3	1	1
Slovenia			25	13		0
Croatia			25	10	3	12
Cyprus						
EU15TOTALS						
EU25TOTALS				2112	13143	9593

Table 23 Monitors EU25, domestic production in 2004 (PRODCOM statistics)

2004	Colour video monitors cathode-ray tube		Flat panel video monitor		Black and white or other monochrome monitors	
	VOLUME	VALUE	VOLUME	VALUE	VOLUME	VALUE
	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)
France						
Netherlands						
Germany						5
Italy	1299	121	2	4	289	45
United Kingdom		20				
Ireland						
Denmark		0			3	1
Greece						
Portugal						
Spain	8	4				
Belgium						
Luxemburg						
Iceland						
Norway						
Sweden						
Finland						
Austria						
Malta						
Estonia						
Latvia						
Lituania						
Poland						
Czech Republic						
Slovakia						
Hungary						
Romania						
Bulgaria						
Slovenia						
Croatia						
Cyprus						
EU15TOTALS					468	
EU25TOTALS			36		468	

During summer 2006, PRODCOM data for 2005 were published and it was decided to include these tables too. The reliability of data seems not to have improved, since there are many empty spaces due to countries not reporting and due to the limitations mentioned earlier. For reasons not explained in Eurostat, Ireland is not yet present in the production statistics of 2005 (September 2006), neither is data for the United Kingdom.

Table 24 Personal computers EU25, domestic production in 2005 (PRODCOM statistics)

	Laptop PCs and palm-top organisers		Desktop PCs		Digital data processing mach//systems	
	VOLUME	VALUE	VOLUME	VALUE	VOLUME	VALUE
	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)
France	70	39	251	168	20	732
Netherlands						85
Germany	6192	4334	736	388	3125	1551
Italy	32	25	45	54	6	8
Denmark	0	0	2	4	3	7
Greece						
Portugal			82	51		
Spain	105	90	59	32	384	135
Belgium			55	45		
Luxemburg						
Iceland						
Norway						
Sweden					34	55
Finland	3	2	23	26	1	1
Austria	141	101				
Malta						
Estonia	3	3	68	27		
Latvia			4	2		
Lituania	0	0	34	16		
Poland	142	91	242	78	5	
Czech Republic						
Slovakia						
Hungary					3338	1253
Romania			98	48	0	1
Bulgaria	0	0	22	3	1	1
Slovenia			18	10		
Croatia			42	15	5	19
Cyprus						
EU15TOTALS						
EU25TOTALS			2732		14285	8838

Table 25 Monitors EU25, domestic production in 2005 (PRODCOM statistics)

2005	Colour video monitors cathode-ray tube		Flat panel video monitor		Black and white or other monochrome monitors	
	VOLUME	VALUE	VOLUME	VALUE	VOLUME	VALUE
	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)	(1000 Units)	(M EURO)
France						
Netherlands						
Germany			67			5
Italy	1210	110	2	2	222	38
Denmark		0			4	1
Greece						
Portugal						
Spain	8	4				
Belgium						
Luxemburg						
Iceland						
Norway						
Sweden						
Finland						
Austria						
Malta						
Estonia						
Latvia						
Lituania			0	0		
Poland						
Czech Republic						
Slovakia						
Hungary						
Romania						
Bulgaria						
Slovenia						
Croatia						
Cyprus						
EU15TOTALS					437	
EU25TOTALS	1341	154	361	190	437	

To be able to show more realistic production data, the project team applied to Eurostat to have the restrictions on confidential data lifted for the purpose of this assignment, but the request was denied. According to Williams [2003], the confidentiality policy is explained the following way:

Confidentiality in PRODCOM

Some national PRODCOM data and EU aggregates are confidential. Confidential data is suppressed and is only available for the PRODCOM staff or researchers or other officials associated with PRODCOM according to the Eurostat Rules of protection of confidential data.

Important producers like Ireland are because of these restrictions totally misrepresented in the statistics.

Later in the report, data on production taken from other sources will be introduced. Data, which are considered more correct than the production data from PRODCOM, due to less restrictions from competition issues.

2.1.2.2 Computers and monitors total EU trade (import and export)

The data on trade published in PRODCOM are derived from the database COMEXT, and are much more complete than data on production. The confidentiality issues may affect some of the national figures, according to Williams[2003], but all relevant data are included in the EU totals. For the investigation the data from COMEXT were also compiled and found to be an exact match to the data from PRODCOM. The data from PRODCOM have been chosen, to avoid the issue of changing coding-schemes in COMEXT between different years in the presentation.

Table 26 EU-25 Total trade (import-export) (PRODCOM data)

		VOLUMES (1000 UNITS)		Value (M Euro)	
Product	**PERIOD**	**EXPORTS**	**IMPORTS**	**EXPORTS**	**IMPORTS**
Laptop PCs and palm-top organisers	2003	1605	11401	1284	7201
	2004	2118	14413	1378	9176
	2005	3704	21325	2271	11499
Desk top PCs	2003	1084	2255	574	820
	2004	1995	3373	730	823
	2005	2125	4181	957	657
Digital data processing mach//systems	2003	1922	6066	1477	1490
	2004	3516	5578	1406	1004
	2005	3382	2405	1215	955
Colour video monitors with cathode-ray tube	2003	135	151	33	46
	2004	93	197	39	53
	2005	95	204	24	55
Flat panel video monitor	2003	242	1157	79	420
	2004	427	1718	146	652
	2005	477	5602	214	1550
Black and white or other monochrome monitors	2003	44	809	13	35
	2004	154	794	10	33
	2005	108	1002	18	34

The figures above show that EU is a large net importer of Laptops, a ratio of import seven times higher than export. The locations for production outside EU are not investigated in detail. Through the survey to the producers it was obvious that relocations by the multinationals to South East Asian production sites is an ongoing move. It will later be covered in more detail.

For Desktop PCs and systems, the figures are much more in balance: imports are about twice the export. Especially for systems, EU seems to have a higher added value, since the value of export and import is almost equal while the number of imported units is twice the exported units.

For monitors, EU is a growing net importer of the more modern flat panel monitors, in 2003 the relation import/export was 4 to 1, but had grown to more than 10 to 1 in 2005. It can also be noted that flat panel monitors represent a very large expansion in trade volume; the import has grown 5 times in 3 years, while the other products have had a much more moderate growth in volume.

2.1.2.3 Computers and monitors domestic trade (import and export)

In the following two tables the domestic trade data for EU-25 countries in 2004 are presented. The data say little about the net consumption in EU, since production cannot be deduced from the data, but they give information on for which countries computers and monitors are important export products.

The tables show that very few of the EU countries are net exporters of any type of computers. The only two net exporters of pure equipment are the Netherlands and Ireland. For systems, with a higher added value, the numbers are different with quite a number of net exporters, which is in line with the need for a knowledge-based industry in Europe.

(The data of Luxemburg seem to be very doubtful, probably a mistake between number of units and the value.)

For monitors, none of the EU-25 countries is a net exporter of any significance, and the huge imbalance between export and import of flat panel monitors can be noted here as well.

Table 27 Domestic trade of computers 2004 (PRODCOM data)

	Laptop PCs and palm-top organisers		Desktop PCs		Digital data processing mach//systems	
	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS
	1000 units		1000 units		1000 units	
France	510	3142	189	1645	1536	1792
Netherlands	9497	7230	747	550	1139	771
Germany	4567	6446	210	318	642	398
Italy	69	2309	114	938	37	396
United Kingdom	1183	6162	517	4106	589	796
Ireland	2420	3035	1744	382	309	34
Denmark	100	579	67	98	7	100
Greece	4	331	1	19	0	38
Portugal	20	315	17	23	3	22
Spain	187	1963	204	501	77	303
Belgium	642	1356	143	79	59	263
Luxemburg	3	3047	81	84829	8	15
Iceland	:	:	:	:	:	:
Norway	:	:	:	:	:	:
Sweden	234	771	30	83	120	125
Finland	107	433	6	23	12	41
Austria	91	474	91	121	92	140
Malta		8	0	1	1	2
Estonia	1	40	1	7	0	2
Latvia	4	33	0	7	0	43
Lithuania	35	90	11	20	2	9
Poland	7	536	13	333	4	35
Czech Republic	187	443	3079	398	2285	2097
Slovakia	13	76	6	135	1	7
Hungary	81	181	101	177	9	18
Romania	0	0	0	0	0	0
Bulgaria	0	49	3	24	5	47
Slovenia	2	62	2	15	84	9
Croatia	5	58	2	32	2	8
Cyprus	0	16	0	3	0	1
EU25TOTALS	3704	21325	2125	4181	3382	2405

Table 28 Domestic trade of monitors 2004 (PRODCOM data)

	Colour video monitors cathode-ray tube		Flat panel video monitor		Black and white or other monochrome monitors	
	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS
	1000 units		1000 units		1000 units	
France	19	63	57	425	8	60
Netherlands	82	97	951	1775	49	45
Germany	38	56	186	468	46	157
Italy	28	22	157	919	113	610
United Kingdom	78	150	2379	2435	26	120
Ireland	1	3	41	59	0	1
Denmark	0	2	25	119	1	2
Greece	0	2	2	94	0	18
Portugal	10	2	30	80	6	22
Spain	4	30	149	607	38	81
Belgium	13	26	173	424	28	41
Luxemburg	0	1	1	7	0	1
Iceland	:	:	:	:	:	:
Norway	:	:	:	:	:	:
Sweden	9	4	31	127	0	13
Finland	1	2	7	30	1	3
Austria	3	6	11	31	1	5
Malta	0	1	0	2	18	1
Estonia	0	1	6	13	0	0
Latvia	0	2	4	17	0	2
Lithuania	0	1	3	3	0	1
Poland	0	4	12	92	0	8
Czech Republic	0	5	29	59		5
Slovakia	0	1	19	47	0	2
Hungary	0	4	5	19	0	2
Romania	0	1	0	5	0	1
Bulgaria	0	1	0	2	0	0
Slovenia	0	1	2	7	1	1
Croatia	1	4	1	7	0	3
Cyprus	0	0	0	1	0	1
EU25TOTALS	95	204	477	5602	108	1002

2.1.2.4 Apparent EU-consumption

Due to the unreliable data on production, the task of calculating the apparent consumption is quite difficult, introducing a high degree of uncertainty. The apparent consumption is to be calculated by taking “imports + production – export”, and due to the misrepresentations in production data, quite a large number of countries are represented as having a negative consumption, which is of course unrealistic.

In the course of the task, a first try was made to plot all data of all countries, in order to find some patterns, which could help generating a complete picture. The intention was to find out if some specific figures were wrong for specific years, which could then be corrected. This proved not to be the case, no obvious patterns were found.

The next line of thought was to search for consumption of important computer parts, like CPUs in PRODCOM, and look for a statistical correlation between that consumption and the production of computers. The coding scheme proved not to be explicit enough, so no correlation could be found.

Instead other sources were contacted, to get what data were available. The first source of data was EITO (a European cooperation between the producers). Then the producers were asked to give as much information as possible on market figures in the industry survey [2006]. The producers were also asked to supply information on which data provider they would use for sales statistics. They all pointed to Gartner Group and IDC, which are commercial data providers, and far too costly to be relevant for this assignment.

Not to overburden the responders, the producers were only asked for data on EU-25 and on some of the larger countries. The subsequent answers did only provide figures of EU25.

Since both EITO and the producers, record sales data instead of data on import and export, for the countries and for EU as a total, the procedure for calculation of apparent consumption was changed, to be equal to the volume of sales. This has the advantage of reducing the impact of stock, which has to be taken into account when using the formula based on export, import and production.

In the survey was included a request for prognoses for quite a long horizon. EITO provides prognoses up to 2007, on Laptops and Desktops. The producers were quite restricted in answers on the future.

Tables 29-31 show the apparent consumption of the major countries as calculated on data from PRODCOM and EITO. This information was provided in the survey, to get comments from the respondents.

Table 29 Apparent consumption, Desktops, for major countries. Data from PRODCOM (2000 – 2004), EITO (2005-2007)

YEAR	Ireland	Italy	France	Germany	Poland	Spain	UK
2000, desktop	-478.004	1.396.677	184.431	787.690	-	101.234	1.838.547
2001, desktop	-2.536.664	1.118.344	195.681	563.335	-	25.297	1.535.429
2002, desktop	-2.743.536	510.066	1.197.920	904.982	203.992	98.435	1099.408
2003, desktop	87.162	2.399.222	3.199.424	4.773.481	213.983	858.860	4.307.948
2004, desktop	114.792	2.490.392	3.436.181	4.673.238	428.079	893.214	4.566.424
2005, desktop	164.754	2.590.315	3.881.697	4.979.217	-	935.968	4.780.247
Prognoses							
2006, desktop	206.079	2.667.797	4.025.116	4.901.330	-	988.879	4.888.657
2007, desktop	241.811	2.765.386	4.093.822	4.755.861	-	1.004.970	4.915.409

Table 30 Apparent consumption, Laptops, for major countries. Data from PRODCOM (2000 – 2004), EITO (2005-2007)

YEAR	Ireland	Italy	France	Germany	Poland	Spain	UK
2000, laptop	868.786	495.433	1.326.373	4.101.971	-	430.009	4.452.755
2001, laptop	549.841	568.088	1.124.608	3.412.759	-	383.801	1.439.322
2002, laptop	570.375	668.377	1.453.383	3.650.046	134.357	550.204	2.370.032
2003, laptop	87.162	1.119.686	1.454.485	2.523.278	172.269	575.320	1.987.743
2004, laptop	114.792	1.390.650	1.841.378	3.154.098	313.801	772.655	2.419.083
2005, laptop	164.754	1.844.044	2.474.567	3.832.705	-	999.558	3.075.689
Prognoses							
2006, laptop	206.079	2.216.222	2.916.323	4.451.002	-	1.166.091	3.584.735
2007, laptop	241.811	2.515.151	3.265.896	5.017.909	-	1.402.871	4.095.955

Table 31 Apparent consumption, data from PRODCOM (2000 – 2004), EITO (2005-2007), for major countries. Monitors

YEAR	Ireland	Italy	France	Germany	Poland	Spain	UK
2000, monitor	6.445	729.447	421.802	59.969	-	49.256	84.391
2001, monitor	11.965	1.003.271	520.782	88.171	-	35.957	42.923
2002, monitor	9.362	1.156.981	431.288	81.301	8.683	117.537	-3.102.706
2003, monitor	4.078	2.029.832	257.953	152.826	6.640	169.575	-1.163.988
2004, monitor	14.682	1.908.639	330.660	215.052	25.490	441.990	16.583
2005, monitor	-	-	-	-	-	-	-

The production and sales data part of the questionnaire was answered by a few of the suppliers. Not to show the exact numbers from each respondent, due confidentiality agreements, the mean values of the answers are provided as a value from the industry as a group. The deviations between the different answers were less than 5%, thus implicating that the mean value representats for the industry opinion well.

The respondents did choose to answer on EU-25, for all years, but with the indication that data from some of the former Russian countries are not included.

None of the respondents gave any answers on individual countries.

In Table 32, the mean value of the respondents` answers are presented in bold letters, while the figures in normal text represent the data calculated from official sources, PRODCOM and EITO.

Table 32 Apparent consumption of computers and monitors, survey answers compared to data from PRODCOM and EITO

	Year	Desktop		Year	Laptop		Year	Monitor
EU15	2000, desktop	2.054.521		2000, laptop	5.938.319		2000, monitor	193.841
	SURVEY	**24 100 000**		SURVEY	**6 100 000**		SURVEY	
EU15	2001, desktop	1.270.287		2001, laptop	12.743.295		2001, monitor	1.097.577
	SURVEY	**22 400 000**		SURVEY	**6 800 000**		SURVEY	
EU15	2002, desktop	3.390.633		2002, laptop	11.586.060		2002, monitor	560.211
	SURVEY	**21 700 000**		SURVEY	**8 000 000**		SURVEY	
EU25	2003, desktop	19.739.653		2003, laptop	9.875.074		2003, monitor	2.403.206
	SURVEY	**24 000 000**		SURVEY	**11 400 000**		SURVEY	
EU25	2004, desktop	20.424.397		2004, laptop	12.231.536		2004, monitor	1.430.935
	SURVEY	**26 200 000**		SURVEY	**15 000 000**		SURVEY	
EU25	2005, desktop	21.898.231		2005, laptop	15.617.607		2005, monitor	
	SURVEY	**28 500 000**		SURVEY	**19 900 000**		SURVEY	**37 800 000**
	Prognoses			Prognoses			Prognoses	
EU25	2006, desktop	22.021.866		2006, laptop	18.135.846		2006, monitor	
	SURVEY	**28 100 000**		SURVEY	**23 900 000**		SURVEY	
EU25	2007, desktop	21.927.681		2007, laptop	20.507.445		2007, monitor	
	SURVEY	**29 100 000**		SURVEY	**27 800 000**		SURVEY	
EU25	2008, desktop			2008, laptop			2008, monitor	
	SURVEY	**29 900 000**		SURVEY	**31 400 000**		SURVEY	
EU25	2015, desktop			2015, laptop			2015, monitor	
EU25	2020, desktop			2020, laptop			2020, monitor	

The table above shows that, there is a huge difference between the data found in open statistics (PRODCOM) and the data supplied by industry.

For Desktops, the error sources in official statistics have been identified (hidden data when few producers in one country) and we have choosen to trust the data from industry for the coming calculations.

For Laptops, the PRODCOM data are almost twice as high as the survey data for the years 2001 – 2002, while the data from the survey is much higher than PRODCOM for the following years. The reason for this is probably due to the fact that the code for Laptops in PRODCOM also includes Palmtops. The Laptop market has been growing four times since 2000, according to Industry, and we assume that the relation of market size between Laptops and Palmtops has changed, thus explaining the differences in numbers between the sources.

Looking into PRODCOM data when plotting graphically, Laptops/Palmtops seems to be better represented in the statistics (less Intra EU-production?) than Desktops. The figures show no disruptive changes, as is often the case for Desktops.

For Monitors, survey data are only available for 2005. The figure supplied is 35 times higher than the number extracted from statistics. The interpretation is that monitors are included in the Desktops in Eurostat data, thus giving the apparent consumption of Monitors to be the number of Desktops + the number of individually represented Monitors. There is very little indication of the type of monitors for the earlier years in the interval. For the later years we can deduce from trade volumes that Flat panel monitors are dominating (5/1) compared to the other types. The ratio is growing very fast, which gives the impression that maybe 85% of the 37 M monitors sold in 2005 are Flat panel.

The results from collecting data from the different sources have given the following approximation of apparent consumption:

Table 33 Approximation of apparent consumption in EU-25, calculated mainly from figures from the industry survey, 2000 - 2008

	Desktops	**Laptops**	**Cathode ray monitors**	**Flat panel monitors**
	(million)	(million)	(million)	(million)
2000	24	6	24	
2001	22	6,5	20	2
2002	22	8	17	5
2003	24	11	10	15
2004	26	15	6	20
2005	28	20	4	26
2006	28	23	2	32
2007	29	28		36
2008	30	31		38

The figures for monitors are very rough approximations, based on the assumptions that all Desktops included a monitor and that the type of monitor is approximately reflected by the distribution of different types of monitors in the trade data.

As can be seen from the data (prognosis), the consumption of Desktops is flattening out to what seems to be a stable level, while the market for Laptops is expanding. The market Desktops can be considered more or less as a pure replacement market.

The distribution of the market for office use and for home use is not presented in official statistics, Eurostat. The survey included questions on this, but only a few of the producers could answer, and then only on the distribution of their own sales.

A recent German study on power consumption labelling [Schlomann, 2005] has produced some information on the distribution between home use and office use of Desktops and Laptops in Germany. According to the study, 30% of the Desktops are in office use and 70% in home use. For Laptops the distribution is the opposite, 60% of Laptops are used in office and 40% at home. Later in this report, the same distribution will be assumed true for Europe as a whole and used to calculate the distribution of the installed base.

2.2 Market and stock data

2.2.1 Task and procedure

The market and stock analyses serve two purposes, first to give the rationale for the base cases which will be defined later on in the assignment, secondly to provide basic economic datasets for the assessments of environmental significance for computers.

In this section estimates of the following will be provided:

- Annual sales data of the different types of equipment covered by lot 3
- Actual stock data, or with a more appropriate term "The installed base"
- Average economic lifetimes of the products.

The data shall as far as possible give the situation in midterm horizon (past 2000) and forward (2010), as well as long term (2020), and references to the years 1990 and 1995 (Kyoto Protocol references).

Due to the unreliable quality of the official data on production, the significant data are supplied by the industry through the survey [2006].

For such a fast moving technology as computers, it is not possible to distinguish in statistics or other sources between equipment to any detail in performance. What was defined as a workstation 10 years ago could hardly be used for ordinary office purposes today. "Moore's law" is still valid, giving an astonishing development speed, making all definitions in performance terms “moving targets”.

The “moving definitions” Desktop and Laptop have therefore been used for the computers, since it is the level to which the products can be traced in the statistics. For monitors the three definitions that can be found in Eurostat: Colour CRT, Monochrome and Flat panel monitors are used. The industry data from the survey [2006] contain very little information on monitors, thus forcing quite rough approximations to be made on the distribution of the different types. The final estimates have been reduced to approximations on CRT and Flat panel.

For the forward looking information, the industry was asked for data and ideas on the developments in midterm horizon (2010), while other sources of “foresight character” have been used for the long term (2020) information.

2.2.2 Results

2.2.2.1 Calculation of installed base of computers and monitors

To calculate the approximate number of units in use, the average lifetime in use for the different equipments must be known. Especially for this type of equipment it must be noted that most computers are replaced, not because they are broken, but due to the fact that the performance is no longer valid. The prime driver for replacement is the software, both operating systems (OS) and application software. The specifications for new operating systems from Microsoft are very often above the performance of a large portion of the installed base.

In this situation, calculation of lifetime (economic) must be based on the producer’s experiences. Some producers have done customer surveys and some have data from take-back systems in some countries. Data on age of computers taken back are however not a very good measurement, since it has been found, that most of the equipment going to the “scrap-yard” has been lying unused for some years before thrown away.

To get some indication on lifetimes, the suppliers were asked for their opinions in the survey. The table below shows the average economic lifetime, calculated as mean values of the answers. The deviations were quite high; ranging from 3.5 years to 7 years for Desktop in home use, so the averages should only be taken as some indications. The “second life” of computer in a second hand market, is not included in the figures. There have been indications that 20% of the equipment goes to a second use, thus adding 2 to 3 years to their lifetime.

Table 34 Average economic lifetimes, opinions of the suppliers, for the first life.

Equipment	**Years**
desktop office	6,00
home	5,83
Laptop office	4,60
Laptop home	4,75
CRT	6,00
LCD	5,88
workstation	7,00

The deviation in the answers was quite high, especially on differences in lifetime for office use and for home use. Some of the respondents claimed that the lifetime was longer in office use, some the opposite. Because of the uncertainties the estimated lifetimes have been simplified to whole years, and assumed the same for office use and home use. The following table shows the lifetimes used for further calculations:

Table 35 Average economic lifetimes, for calculation of installed base.

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

Integrating the data in Table 33 (apparent consumption), over the approximated lifetimes, the following very rough estimation of equipment in use is calculated (since the integration is to be made 6 years back, and there are no reliable data before 2000, the calculations are made from 2005 and forward). For laptops, the expected lifetime is shorter, thus making it possible to present an estimate also for 2004. For Flat panel-monitors, no sales were reported before 2001, thus allowing calculation of installed base from 2001 and forward.

Table 36 A very rough approximation over units in use in EU 25.

	Desktops	Laptops	CRT-monitors	Flat panel monitors
	(million)	(million)	(million)	(million)
2004		46,5		42
2005	146	60,5	81	68
2006	150	77	59	100
2007	157	97	42	134
2008	165	117	25	167

Applying the distribution home-office taken from [Schlomann, 2003], the following table over installed base in office and home is produced:

Table 37 Approximate installed base of computers and monitors, in office and in home use.

	Desktops		Laptops		CRT-monitors		Flat panel monitors	
	(million)		(million)		(million)		(million)	
	Office	Home	Office	Home	Office	Home	Office	Home
2004			28	18,5			13	29
2005	44	102	36,5	24	24	57	20,5	47,5
2006	45	105	46	31	18	41	30	70
2007	47	110	58	39	13	29	40	94
2008	49	116	70	47	7,7	17,5	50	117

For CRT-monitors and Flat panel- monitors, the distribution between office and home use has been assumed to be the same as the distribution for Desktops.

2.2.2.2 Estimations of market and installed base 2010

The survey did not give any estimation of sales volumes after 2008, but as will be shown later, no major changes of the format of computers are expected in that time frame.

[Schlomann, 2003] gives some estimates on predicted German installed base in 2015. For the office, the number of computers is expected to increase by 10%, the expansion completely by Laptops. For home use a German expansion of 40% is expected until 2015, with a focus on Laptops.

Comparing this with the estimates for Europe as a whole until 2008 given in the survey, the survey indicates a bigger expansion. This can be explained by the high computer maturity in Germany and other West European countries, compared to the new member states, thus giving room for a bigger expansion.

With the available information the best estimates for 2010 are probably calculated by extrapolating the trends in Table 37 for another two years, giving the following:

Table 38 Rough approximation of installed base of computers and monitors, 2009 – 2010.

	Desktops		Laptops		CRT-monitors		Flat panel monitors	
	(million)		(million)		(million)		(million)	
	Office	Home	Office	Home	Office	Home	Office	Home
2009	50	123	82	55	2	5	55	130
2010	51	130	94	63	1	1	60	140

The expansion rate of Flat panel-monitors has been reduced compared to the extrapolation, since the sales in the years preceding 2009 have consisted to a large part of replacements for old CRT-monitors. As indicated before, the major part of the expansion of the market is based on Laptops, while the Desktop market is a replacement market, except in the new member states.

2.2.2.3 Retrospect to 1995

For Kyoto references, relevant data for 1995 and 2000 are needed. The production data in Eurostat are very sparse, to such a level that it is not useful to present by nation. Laptops and flat panel monitors are not yet present in the statistics. Eurostat published data for the first time in 1995, thus not making any earlier data available, making it impossible to calculate the installed base.

In 1995, the computer was not yet a communication device to any large extent, Internet was breaking through, initiating a large expansion of the installed base.

Table 39 Production 1995, PRODCOM data.

1995	**Desktop PCs**		**Colour video monitors cathode-ray tube**	
	VOLUME (1000 units)	VALUE IN (M EURO)	VOLUME (1000 units)	VALUE IN (M EURO)
EU15TOTALS	1683	4560	64	38

Table 40 Extra EU trade 1995, PRODCOM data.

1995								
	Desktop PCs		**Colour video monitors cathode-ray tube**		**Flat panel video monitor**		**Monochrome monitors**	
	VOLUME (1000 units)	VALUE IN (M EURO)	VOLUME (1000 units)	VALUE IN (M EURO)	VOLUME (1000 units)	VALUE IN (M EURO)	VOLUME (1000 units)	VALUE IN (M EURO)
EU15-export	93077	2748	52	34	15	8	50	15
EU15-import	3857	2257	91	43	44	16	382	34

The quality of the data has obviously not yet been stabilized; the export volume is not in line with the value of the export. The best estimate possible from the figures supplied is that the market in EU15 was roughly 2 million Desktops in 1995.

2.2.2.4 Retrospect to 2000

In 2000, Eurostat was better established, giving more reliable data. Internet had made the breakthrough at least in office, thus generating a large expansion of the computer market.

Table 41 Production 2000, PRODCOM data.

2000	**Laptop PCs and palm-top organisers**		**Desktop PCs**		**Colour video monitors cathode-ray tube**		**Flat panel video monitor**	
	(1000 units)	(M EURO)	(1000 units)	(M EURO)	(1000 units)	(M EURO)	(1000 units)	(M EURO)
EU15TOTALS	6844	9311	7442	7398	736	155	10	36

Table 42 Extra EU15 trade 2000, PRODCOM data.

2000												
	Laptop PCs and palm-top organisers		**Desktop PCs**		**Digital data processing mach//systems**		**Colour video monitors cathode-ray tube**		**Flat panel video monitor**		**Monochrome monitors**	
	(1000)	(M EURO)	(1000)	(M EURO)	(1000)	(M EURO)	(1000)	(M EURO)	(1000)	(M EURO)	(1000)	(M EURO)
EU15-export	1234	1031	860	939	686	1092	59	38	59	26	57	15
EU15-import	7172	4924	2915	1009	830	939	182	76	120	75	729	46

According to the data from PRODCOM, the Desktop market was 9.6 M units, while the industry survey indicated a market of **24 M Desktops.** For Laptops, the data from PRODCOM include Palmtops, making the figures from the survey much more reliable, indicating a market of **6 M Laptops** for EU25.

The market data for monitors are obviously not yet reliable, and the survey did not give any information, thus generating the assumption that the market for **monitors** was roughly the same size as the market for Desktops, **24 M units.**

Calculations on the installed base in 2000 cannot be made on the existing data to any reasonable quality.

Comparing the data from 1995, 2000 and 2005 it can be noted that the external trade values (import + export) for Laptops have gone from 0 in 1995, to almost 14.000 M Euro in 2005. For Desktops, the trade values have gone from 5.005 M Euro to 1.614 M Euro in the same period. Apart from the very large expansion in sales volume on Laptops, a different production pattern may also explain the very large difference in the development; Desktops are often assembled close to the market thus not showing up in external trade.

Flat panel monitors have also evolved to a very large market in short time. In 1995 there was no noticeable trade and in 2005, the external trade represented a value of 1.760 M Euro.

2.3 Market trends

2.3.1 Consumer tests

2.3.1.1 Desktops and laptops

Stiftung Warentest is a German foundation that helps consumers by providing independent and objective tests of consumer products. In February 2006 they published a test of ten laptops and six Desktops where they tested the computers both within the group (Laptops/Desktops) and also between the two groups. The test is (as of 2006-10-12) available for purchase at. [Stiftung Warentest, 2006]

The tested laptops were:

- Benq Joybook R53 G16 (Best in test)
- Toshiba Satellite L20-120
- Acer Aspire 1652WLMi
- Samsung R50 WVM 1730
- Asus A6KM-Q002H
- Dell Inspiron 1300 Advanced
- Fujitsu Siemens Amilo A 1667 G
- Sony Vaio VGN-FS315M.G4
- Hewlett Packard Pavilion ze2356ea
- Maxdata NB ECO 4100IW DE

And the tested Desktops were:

- Dell Dimension 5150 Large (Best in test)
- Hewlett Packard Pavilion t3257.de (Best in test)
- Medion Multimedia PC Intel P4 640
- Acer Aspire E300
- Fujitsu Siemens Scaleo Pi
- Packard Bell iMedia 5191

When comparing Desktops vs. laptops they concluded that laptops have well enough computing capacity for "normal" use, and have the advantage of being portable. All computers tested, laptops and Desktops, were considered to be good enough. On the other hand, if the user doesn't need the portability, a Desktop is a better choice by the following reasons:

- Desktops have better computing power, especially valid for heavy uses such as video editing or gaming
- Desktops have larger hard drives
- Desktops are better equipped, they have for example more USB ports, memory card readers

- Desktops are more flexible, it is possible to exchange and add components such as hard drives, graphic cards and so on
- Desktops have generally better ergonomics, it is easier to get good ergonomic working posture

The evaluations were based on the following criteria:

- Computing power (25% laptops, 40% Desktops)
  Using benchmark applications for office, multimedia and games
- Handling (20%)
  Evaluating documentation, recovery possibilities, day-to-day handling, laptop weight and Desktop build quality
- Screen (15% laptops)
  Evaluating the screen quality and external display possibilities
- Battery (15% laptops)
  Evaluating the battery operating time, battery drain warnings and the recharge times
- Versatility (10% laptops, 25 % Desktops)
  Evaluated the enclosed software and hardware and communication and expansion capabilities
- Environmental characteristics (15%)
  Evaluated the noise and power consumption in use, stand by and off mode

2.3.1.2 Monitors

Tom's Hardware Guide is a web site where they review and test hardware, mostly aimed for computer enthusiasts. They regularly test monitors, and in the end of March 2006 they compared eleven 19" LCD monitors.
The test is (as of 2006-10-12) available at [Tom´s Hardware]

The tested monitors are:

- BenQ FP91V+
- BenQ FP91V
- Hyundai Q90U
- NEC 1980FxiNEC 90GX2
- Samsung 960BF
- Samsung 970P
- Sony MFM-HT95
- ViewSonic VX922
- ViewSonic VP930
- Xerox Xa7-192i

All monitors share the same resolution of 1280*1024 pixels and have at least VGA and DVI connections while the specified contrast varies between 600:1 and 1000:1, the specified brightness varies between 250 and 450 nits and the specified response time varies between 2 and 18 ms.

The tested properties are design, ergonomics, connectivity, delta tracking, contrast, colour gamut, spatial uniformity, latency, overshoot and “In Use”.

They summarize the test with stating that the pace of monitor technology improvement is currently huge, as is the rate of getting new monitors to the market. One current trend is that the manufacturers design monitors for specific applications, such as office production, gaming or photo and graphic production. This makes it difficult to select a test winner since different monitors are suitable for different uses. However, they mention the ViewSonic VP930 as it is good in many respects, while the ViewSonic VX922 may be better suited for gamers and the Samsung 970P might be best among these monitors for photo retouching.

2.3.2 Production structure

In the discussions with the producers, the general characteristics of the production structure and supply chain were covered. The patterns seem to be similar for many of the producers:

The design is often a shared operation between Europe, US and South East Asia, thus getting costumer preferences from several markets.

The Integrated circuits and other components are produced mainly in South East Asia.

For Laptops and Displays (LCD) the whole production is located to South East Asia, while Desktops due to the more modular design, very often are assembled close to the market in Europe, from parts produced in South East Asia.

2.3.3 Actual markets shares by producer

Detailed data on market shares and market penetration are only available through commercial data sources, therefore the producers were each asked for their own market shares. Since not all producers have answered the survey, the picture is not complete, but gives an indication on who are the major “players” in different market segments.

During the discussions with industry, they all pointed to the fact that around **10% - 35%**, of the market for Desktops is held by so called **“White boxes”**, that is more or less temporary suppliers operating without a brand, buying surplus details on the global market to compete in the low price segment. These suppliers are by nature very hard to reach for voluntary agreements concerning environmental performances. The White boxes are more common on the private market.

Due to the sensitive nature of the figures on market shares, the observations are limited to indications on who are the major players on the different markets.

The dominating suppliers of office Desktops seem to be Dell and HP. For Desktops in home use, Packard Bell has a market share similar in size with HP and Dell. Apple, Lenovo (former IBM), Acer and NEC are also present.

For laptops, HP, Toshiba and Dell are dominating the office market, while the home market is shared between HP, Toshiba, Dell, Packard Bell and Sony. NEC has a relatively small market share.

For CRT-monitors, HP seems to dominate.

In the LCD-monitor market, Dell, Acer, Samsung and HP all have a market share above 10%. Philips, Fujitsu-Siemens and LG have market shares around 5% each.

The actual market shares are not shown in figures, since some of the suppliers opted not to give specific figures due to principle.

2.3.4 Prospect 2010, Market and features

Taking the speed of development into account, it would be possible with major changes in system format and usage pattern. Higher technological performance, like processor speed and higher memory density could lead to a very fast move towards smaller devices, and a fast integration with the mobile phone.

In the survey to industry [2006], a number of questions along different possible directions of that kind were asked.

In the answers, the general impression delivered, that for the short term future (2010), the major trend will be to use new technology to enhance the performance in existing formats. The major driver for this is the coming introduction of the next OS (operating system) from Microsoft (Vista), which will demand as much performance as can be generated in the coming years. Market impact from Vista is expected to start in 2007, and an accelerated shift out of older equipment is expected. This is mainly reflected in the estimated market figures in earlier chapters.

The industry are foreseeing a breakthrough for connectivity in several steps, in short term by network technologies like WWAN and WIMAX, in longer term on more advanced technologies. This will put increased pressure on battery operation and longer running time on battery. More energy efficiency is expected in short term through more efficient components, but also gradually better batteries.

For laptops, the move for higher efficiency will be balanced by the need to make the devices thinner and less heavy in physical respect.

A change in display technology is expected, but it seems from the answers uncertain whether the technology with LED-backlights (a development of the older LCD technology, but environmental positive due to reduction of mercury) will be ready for market before 2010. This seems to be a rather conservative judgement since several other sources have indicated that the next technology OLED may come into market before 2010. The development of monitors is also continuously driven by accelerated demands from the users for better resolution and better performance for showing moving pictures. The producers of monitors also have to balance between demands for design and demands for workplace quality.

According to “Display search”, the average prices of Flat panel computer monitors are shrinking at an exponential rate, the cost per square meter display area has gone from 10.000$ in 1999, to 2.000$ in 2005, indicating a continued move to larger and cheaper displays.

New memory technology is expected to improve the speed of hard-drives in the near future. The very fast evolution of flash memories will offer shortterm possibilities for energy reduction by partly replacing hard discs.

In the case of home entertainment, the suppliers show quite different opinions whether the computer will move into the living room and become the centre device for digital TV, DVD and so on. Several of the respondents express the view, that the market will supply specialized equipment for this type of applications, while others believe the general computer will gradually take over from the TV.

Several of the answers point to a gradual need for a home server, continuously on, to serve as communication centre. They also point to the problem of wireless LANs, which demand the computer to stay alive to keep the connection running, thus limiting the ability to go into energy saving mode.

In summary, for the short term (2010), the existing formats will prevail. A new wave of replacement sale will start around 2007. The numbers in previous sections point to a continued expansion of Laptop volume, while Desktops are levelling out to a steady volume of pure replacements. The sale of CRT-monitors is quickly declining in volume but with some indications for a continued demand in niche markets and niche applications.

2.3.5 Prospect 2020, Market and features

15 years in the future is a very long time, dealing with fast moving technology as ICT. According to the futurologist Ray Kurtzweil [2004] all Information Technologies double their power every year (price, performance, capacity and bandwidth). If this vision holds true, we are, when looking towards 2020, trying to understand how mankind will use technology 32.000 times as powerful as today´s (2 to the power of 15). It must be observed that not all experts agree on the validity of Moore law beyond 2015 and claim a slower expansion rate after that, but on the other hand many have done so before and the evolution has repeatedly proved them wrong and some are even arguing that the speed of Moore’s law is going up.

Based on such enormous developments, a fifteen-year prediction can only be in the form of a discussion on early observed trend babies and key questions around them.

2.3.5.1 *Will the current computer format prevail?*

We already have the technology to make very small handheld devices with the full capacity of an ordinary PC - while at the same time having functionality as cell phone, GPS and camera. With new coming communication technologies it would be possible to be connected everywhere and every time through a palmtop/mobile phone with all necessary capacity for the kind of personal computing we are used to.

The limitations of this movement seem to be the user interface, before these kinds of devices can make the PC or Laptop redundant, completely new ways of interacting with the device must be invented. Technologies like speech recognition and displays in eyeglasses are tested but have yet to prove the usability before any major change of format can take place.

Anyhow the evolution of the mobile phone into a multipurpose device has shown that more and more daily tasks are executed on such devices. The phone will for certain be a computer, but so far with a very limited user interface.

One important possibility is that new short distance wireless technology will open new possibilities to use the phone as the computer, always carried with you, but connecting to wireless interface devices in the office or at home and in public places - thereby obtaining the interface of the computer.

2.3.5.2 *Will the net takeover?*

Some foresights (Cisco) [2006] are indicating a long term development where the network will be the computer, meaning giving lots of users the ability to "borrow computer power from each other when needed" thus reducing the need for local capacity. They also indicate that more and more applications will be accessible over the net (a development currently pursued by Google), reducing the need for local storage and local maintenance of software.

For some applications, this may be a commercial success, but computer power does not seem to be a limitation in the future.

The network capabilities will for certain change the ways we are working and the way we share information both locally (in the company and in the community), and globally. Nearly unlimited capacity for video-meetings and other ways of remote communication will give the opportunity to work from anywhere. 0ne driver for such a development will probably also be the cost of energy and possible future limitations on travels (oil price).

2.3.5.3 *Will advancements in technology be used for reducing prices instead of enlarging capacities?*

For the short term, the industry has given a clear answer that the specifications for new operating systems will use all possible capacity (within reasonable price limits), but with increasing capacity per unit, it is quite possible that the market, in the future, goes more definitely for lower prices instead. Since such a development would affect the revenues of the total industry, it is likely to meet commercial interests forcing an ever increasing need for capacity and consolidation of the companies in the business.

2.3.5.4 Will TV, DVD, CD be replaced by computers, to give more interactivity?

The introduction of digital TV, streaming video, massive supply of news over the Internet and other related developments, will increase the opportunities of using a computer as a "communication centre in the living room". It is still under debate whether personal computers will be used or whether the media industry will provide other configurations of computerized equipment for such applications.

The development of network capacity and storage capacity will open for completely new services allowing much more of interactivity and personal choices.

The big question is whether the media industry and computer industry will amalgamate to one industry or if the now two industry branches will pursue different directions of development

2.3.5.5 Will voice on IP dominate, will the computer be a phone or vice versa?

Voice on IP is expanding rapidly, the direction of development on devices for connection is still under debate, IP-phones may be simple, but will not so far give the versatility of the computer for video, file interaction and so on. When voice on IP becomes the dominating tele-communication, it may become necessary or practical for every home to have a server always on, to manage the connection and the connectivity.

2.3.5.6 Will everything in the household be connected?

Some future studies see the need, desirability and possibility to make all household installation (like refrigerators, stoves, washing machines, the heating system and so on) computerized and connected. The need for such developments and the business potential are generally yet to be proven, but if there will be a market, the computing structure of the household may be effected quite a lot.

2.3.5.7 Will we have computer screens as art?

The cost of large screens is decreasing rapidly, so there might be other usage patterns than pure communication in the traditional sense. With decreased cost, we might use computer screens on the wall showing art, to fit the moment. We could even use computer screens to improve the reality, show a nice outside view instead of the boring backyard. The possibilities will be limitless, but what will the consumer's desires and preferences be?

2.3.5.8 Carried Artificial Intelligence, improving our decision capacity everywhere?

The development of AI has not quite lived up to expectation yet. Still with much increased computing power and more agile user interfaces, AI may come to a daily use by everybody, improving the ability to take daily decision in a more informed and optimal way. In 15 years time, the technology might be here, but what would be the effects? What will be the impact on the perception of knowledge and the market value of education? It would surely be revolutionary, but is it desirable?

2.3.5.9 Conclusion 2020

It is now ten years since the breakthrough of the Internet. In those times information was more or less exclusively confined to paper. There were computers but they were heavy and clumsy and very often crashed. In fifteen years´ time, the opportunities of applying and using computer technology will be huge. The speed of knowledge acquisition is exponential, most written text can be found in some form on the web, Google has effectively already copied all the world´s known books. Music and movie industry are heavily affected. The futurist Kurzweil even claims computers will disappear from our sight by 2010. The directions for applications will be dependant both on what producers choose to develop and what will be accepted by the customers. The development speed makes predictions practically useless for such a long timeframe - but we will all be affected.

This chapter was included to give indications of possible multidirectional futures. The directions of applications will naturally affect industry and industry structure immensely.

2.4 Consumer expenditure database

2.4.1 Comparison of average unit prices 2003 – 2005

Since the capacity of especially Desktops and Laptops varies a lot between individual units, and even more over the years, it is almost impossible to make any relevant price comparisons at a detailed level. It can be observed in general that the market tends to decide a generally accepted price by the consumers for one physical unit, and then supply as much performance as is possible for that price. A closer study would probably reveal a pattern with different accepted prices for different consumer segments.

This observation is in general supported by the table below, where the average unit prices have been calculated, based on import volumes and values, taken from PRODCOM, over as many years as available in the statistics.

Table 43 Average unit prices, calculated from PRODCOM import data

Year	Laptop	Desktop	System	Colour CRT	Flat panel monitor	Monochrome monitors
	EURO	EURO	EURO	EURO	EURO	EURO
1995		585		480	369	91
2000	687	346	1131	420	627	64
2003	632	364	246	306	364	44
2004	637	244	180	273	380	43
2005	539	157	397	273	277	34

From the table, it is obvious that Laptops had a very stable price from 2000 to 2004, but that the price started to drop in 2005. The prices for Desktops have been shrinking continuously thus not supporting the theory above. All other unit prices have been falling in general. The clear exception is systems, but this is probably due to the wide variety of intellectual content and value added included under this code.

It must be noted that the prices in this calculation are not based on retail prices, but on the prices when passing the customs.

From the survey [2006], the following weighted mean retail prices for the most sold version of equipments from each producer have been calculated:

Table 44 Weighted mean value of retail prices, 2005, data from survey.

Desktop Office	Desktop home	Laptop office	Laptop home	CRT	LCD
Euro/unit	Euro/unit	Euro/unit	Euro/unit	Euro/unit	Euro/unit
620	520	1242	990	73	201

The bases for the calculations are: for Desktops office 3.3 M units, for Desktop home 1.1 M units, for Laptop office 1.6 M units, for Laptop home 0.8 M units, for CRT 0.7 M units and for LCD 1.3 m units.

It must also be noted that for computers, the real cost for the consumer also depends a lot on the software. In the figures in the table it is unlikely that any major part of the cost for software is included. Most computers have the major part of software installed by the retailers or by the users.

2.4.2 Electricity rates

The electricity rates do change over time. Since the study shall cover the year 2005, the [EUROSTAT] rates from 1 July 2005 will be used in the calculations in subsequent tasks.

Table 45 Household electricity rates. (Standard Consumer Dc, Yearly consumption 3500 kWh of which 1.300 kWh by night) July 2005 incl. all taxes.

Country	Electricity rate (€/100 kWh)	Tax share of price (%)
EU- 25 average	13,6	23,8
Austria (AT)	13,91	31,8
Belgium (BE)	14,29	23,0
Cyprus (CY)	12,03	14,6
Czech Republic (CZ)	8,71	16,0
Denmark (DK)	23,20	58,5
Estonia (EE)	7,13	15,2
Finland (FI)	10,38	25,2
France (FR)	11,94	24,2
Germany (DE)	18,01	25,2
Greece (EL)	6,94	8,2
Hungary (HU)	11,24	20,0
Ireland (IE)	14,36	16,6
Italy (IT)	20,10	24,8
Latvia (LV)	8,29	15,3
Lithuania (LT)	7,18	15,2
Luxembourg (LU)	15,02	12,7
Malta (MT)	7,69	4,9
Poland (PL)	9,35	23,2
Portugal (PT)	13,80	5,1
Slovak Republic (SK)	13,30	16,1
Slovenia (SI)	10,49	16,7
Spain (ES)	10,97	18,0
Sweden (SE)	13,33	39,6
The Netherlands (NL)	19,6	43,5
United Kingdom (UK)	9,26	4,9

During 2005 the prices rose by 5% on average for households and by 16% for industrial consumers.

2.4.3 Repair and maintenance costs

Regarding the repair and maintenance cost, there are some different ways to handle this:

2.4.3.1 *Service agreement*

For the computer and monitor market, an often used way to handle repair and maintenance cost, 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.

Quite often these service agreements are already included in the purchase prices.

2.4.3.2 *Upgrading*

Computers (but hardly monitors) can be upgraded to fulfil a better performance by changing processors, hard disk drives, graphics cards and other parts. This is an opportunity sometimes used by private consumers, but hardly by companies. The industry gave some figures saying approximately 2% of the customers use that opportunity. We assume that the cost for an upgrade is about 200€.

2.4.3.3 *Repair*

Computers

Those who do not have a service agreement do repair their computers when they break. Most computers break somehow sometime. Figures on repair cost were very difficult to find, but contacts to a couple of computer repair companies gave some information. An ordinary repair cost is about 75€ for labour for identifying and changing some broken hardware, which have different costs, but often between 50 and 150€.

Monitors

Monitors do mostly have a three-year warranty, within which time broken monitors are repaired for free. The repair cost of a monitor is often about 120€ which is far too much to pay for a monitor of older age than 3 years, since a new one does not cost much more than that.

Software

A quite common repair and maintenance cost for computers is the cost to provide the computers with new or upgraded software. A study referred to by Tim Landeck [Total Cost of Ownership] says 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 do very often have to reinstall software, such as operating system at a cost of approximately 75 €.

2.4.3.4 Conclusion repair and maintenance cost

We assume an extra cost of 125€ for repair and maintenance for computers in their lifetime. For computers monitors, we assume no extra cost for repair and maintenance.

2.4.4 Disposal costs

Disposal costs for computers and monitors, come under the WEEE directive, which means that the producer has the responsibility to take care of the equipment after use. That means that in a past WEEE situation there will be no cost for the consumer related to the disposal of this equipment, except from the higher price the manufacturer might use due to their disposal costs. Today the situation differs very much from country to country, and even from region to region within the countries. The WEEE directive is working in Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Luxembourg, The Netherlands, Portugal, Slovakia, Spain and Sweden. On the other hand WEEE system is not yet completed in Cyprus, France, Italy, Latvia, Lithuania, Malta, Poland, Slovenia and UK.

Since Sweden has a ”producer responsibility” legislation since 2001, even before the WEEE directive, there might be of interest to highlight up some of the information from it:

2.4.4.1 Swedish example of disposal costs

“El-kretsen”, the Swedish electric and electronic waste collection company, did collect 126 millions kg electronic waste 2005 (incl. refrigerators and freezers from. 13/8-2005). Without refrigerators and freezers: 112 million kg. Approximately 12% were computers and monitors. “El-kretsen” is collecting almost all electric and electronic waste in Sweden, but some of it comes to the recycling companies from other sources, perhaps 8-10%.

Since the introduction of producer responsibility 2001, the increase has been 15-20%/year, most of it last year, probably due to the WEEE- directive.

Table 46 Total cost for disposal 2005 Sweden, assumption.

	kg	SEK/kg	M SEK	1000 Euro
Desktop computers	5,7 M	2,0	11,4	1140
Laptop computers	140 000	2,5	0,35	350
CRT monitors	10,2 M	4,0	40,8	4800
LCD monitors	96 000	3,5	0,33	330
total				**6620**

For a CRT of 17” and of 16 kg, it means a cost of approximately 6€

The costs for the manufacturers are calculated on their market shares to decide who should pay what. For example, if one company has 20% market shares of CRT, it would mean 0.2*4800 000 €, which is about 960 000 €. That is independent of if they did really provide the products, which are physically sent to the end of life treatment. So even if a manufacturer is new to the market, they have to pay for end of life for “their” share of products.

2.4.5 Interest and inflation rates

The following table shows inflation and interest rates for the EU25 as published by Eurostat and the ECB. [2005]

Table 47 Interest rate EU25, 19 Jan 2006.

Country	Inflation rates [%] (1)	Interest rates [%] (2)
Belgium (BE)	2,8	3,4
Czech Republic)CZ)	1,9	:
Denmark (DK)	2,2	3,4
Germany (DE)	2,1	3,4
Estonia (EE)	3,6	-
Greece (EL)	3,5	3,6
Spain (ES)	3,7	3,4
France (FR)	1,8	3,4
Ireland (IE)	2,2	3,3
Italy (IT)	2,1	3,6
Cyprus (CY)	1,4	5,2
Latvia (LV)	7,1	3,5
Lithuania (LT)	3,0	3,7
Luxembourg (LU)	3,4	:
Hungary (HU)	3,3	6,6
Malta (MT)	3,4	4,6
The Netherlands (NL)	2,1	3,4
Austria (AT)	1,6	3,4
Poland (PL)	0,8	5,2
Portugal (PT)	2,5	3,4
Slovenia (SI)	2,4	3,8
Slovak Republic (SK)	3,9	3,5
Finland (FI)	1,1	3,4
Sweden (SE)	1,3	3,4
United Kingdom (UK)	2,0	4,5
EU 15	2,2 (3)	3,42 (3)
EU 25	2,1	3,9

2.5 References

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  or in German at http://hardware.thgweb.de/2006/04/07/19_zoeller_13_lcd_monitore_im_vergleich/

  and Swedish at http://www.tomshardware.se/skarmar_och_tv/skarmar/20060322/.
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- Tim Landeck [Total Cost of Ownership] http://www.thesnorkel.org/toolkit/articles/TCO_Final%20.pdf
- Annual Inflation (%) in Dec 2005 Eurostat "Euro-Indicators", 7/2006 - 19 January 2006
- Source: ECB long-term interest rates; 10-year government bond yields, secondary market. Annual average (%), 2005
- http://www.stiftung-warentest.de/online/computer_telefon/test/1335574/1335574/1336536.html
- *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 they do cover the main players for both computers and monitors, and also covering companies from Europe, The USA and Asia. The number of respondents to the questionnaire was 16.

3 Consumer behaviour and local infrastructure

Introduction

The main sources for information have been several international studies on usage patterns.

The general picture of computer usage pattern is an elusive one, in spite of the fact that several studies are available. “Computer and Monitor usage pattern” is used in the meaning of how much time a computer and monitor 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.

3.1 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.

3.1.1 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.

3.1.2 Definitions of operational modes

The definitions of operational modes used in this task are based on the Energy Star modes for computers and monitors respectively, described in task 1.3.3 and 1.3.4. The short versions are:

”**Off**” includes soft off (computer turned off by software or power button but still connected to mains) and hard off or disconnected.

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

"**Active/Idle**" includes all power states between idle and high (maximum power usage).

3.1.3 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, such as "chat-sites" that tend to make the users to have the computer always turned on.
- If the computer appears "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, the equipment should automatically enforce an optimal usage pattern. A non-sustainable system configuration will automatically lead to a non-sustainable usage pattern.

3.1.4 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, such as active/idle, sleep and off and hours a year and make a general average of it. The information and how the normalisation was done are described below. In Table 53 the resulting mean values from all sources are presented as the usage pattern that will be used in the subsequent tasks of this study.

3.1.4.1 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.

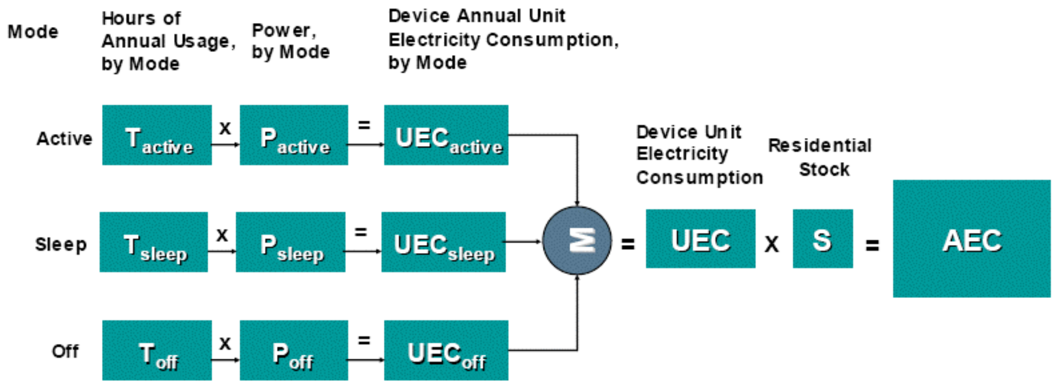

Figure 1 TIAX annual energy consumption, methodology.

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 are responsible 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.
- 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%

Table 48 TIAX 2006, Residential, hours/year in each mode.

	Active	**Sleep**	**Off**
Desktop	2954	350	5456
Laptop	2368	935	5457
Monitor	1861	881	6018

3.1.4.2 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 49.

Table 49 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 summed up as “Active/Idle”, which is the best estimate considering the definitions in task 3..1.2. For “Monitor”, CRT and LCD are averaged.

3.1.4.3 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 sleep mode, and 13 h/d in Off-mode. [http://www.eu-energystar.org/en/index.html].

3.1.4.4 *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings [TIAX LLC, 2004]*

Table 50 TIAX user patterns.

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.

The report also states, that for Desktop PCs, the “power management on” rate is somewhere between 6% and 25%.

3.1.4.5 *Monitoring Home Computers, by MTP*

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. [MTP, 2006]

Method

The MTP 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

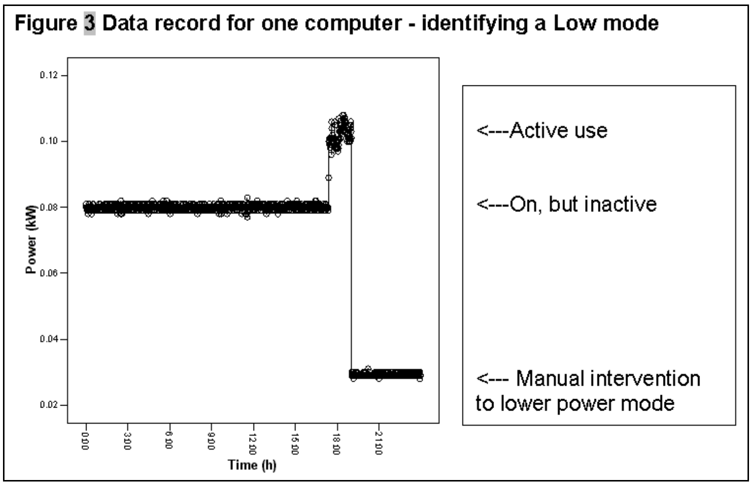

Figure 2 Data record for one computer – identifying a Low mode. [MTP, 2006, p. 13]

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 51 Usage pattern from MTP'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.

3.1.4.6 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)

Figure 3 EEDAL 06, PC on-time. [Kurt Roth, 2006]

3.1.4.7 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” (0W power or disconnected) is negligible as compared to “Soft Off” (shut down through software, still some power use)

[Karine Thollier, 2006]

3.1.4.8 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 are responsible for 14,2% of the energy consumption in office buildings, and 15% when electric heating is excluded.

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

3.1.4.9 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 approcimately 50% of the time.

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

3.1.4.10 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]

3.1.4.11 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]

3.1.4.12 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 Assessment 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 52 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]

3.1.4.13 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]

3.1.5 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.

3.1.5.1 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.

3.1.5.2 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.

3.1.6 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 summary in the table below 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 a position to weight the data for quality, a non-weighted average have been used.

- *Table 53 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	4305	49
		Sleep	2873	33
		Active	1582	18
Laptop	Office	Off	3153	36
		Sleep	2995	34
		Active	2613	30
	Home	Off	4468	51
		Sleep	2904	33
		Active	1388	16
Monitor	Office	Off	2375	27
		Sleep	3798	43
		Active	2586	30
	Home	Off	4835	55
		Sleep	2636	30
		Active	1289	15

The operational modes, from task 3.1.2, are defined as:

- ”**Off**” includes soft off (computer turned off by software or power button but still connected to mains) and hard off.
- “**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).

3.1.7 Conclusions regarding usage pattern

In order to arrive at usage patterns that can be used in the Lot 3 study, all available usage pattern studies have been considered. The resulting average usage patterns need not be very common or even realistic if the variations are very large. For example, if people either use power management or they do not, nobody would recognize himself or herself in the “average user”. This being said, below follows an attempt to explain the resulting average usage patterns.

Office computers are in active use during less than one third of the time. This can correspond to active time in average 10.3 hours per day 220 working days per year. The assumption is that people turn the product on when arriving to work, and leave it on active mode during the full day, without activating sleep mode until they leave at night (long time settings of inactivity before activating sleep mode). Sleep mode is activated a little bit more than one third of the time, corresponding to the nights between the working days. Off is only used a little bit more than one third of the time, which can correspond to weekends, bank holidays and vacations. The usage pattern is very differentiated, and we know that some people will leave the product in active mode even during night, while others turn it off or activate sleep even during the working day.

Office monitors are more often in sleep mode, probably due to that “old” power management settings more often include shorter time of inactivity until sleep mode is activated. There is also a habit described, where the monitors are left in sleep also during night.

For home computers the active time is less than one sixth. The assumption is that people more usually turn their products off when not in use at home. The rest of the time is sleep and soft off. Hard off time is negligible.

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

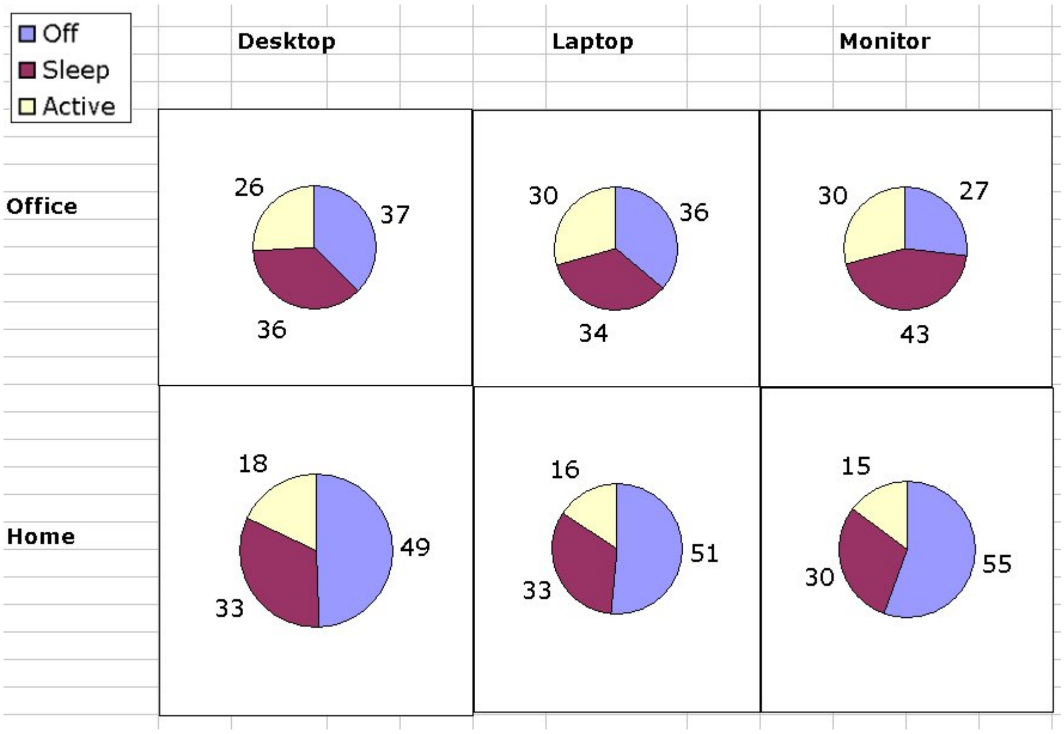

Figure 4 User patterns mean values from all sources.

3.2 End of Life behaviour

3.2.1 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 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. (Storage time after use is not included in the life time)

Table 54 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

3.2.2 Repair- and maintenance practice

3.2.2.1 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.

3.2.2.2 *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.

3.2.2.3 *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 lifetime. Some repairs are also made within the warranty time and cause therefore no extra costs. Since laptops have a shorter life, their annual repair cost (after warranty) is higher than for desktops.

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.

3.2.2.4 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. Maintenance, repair and service transportation is assumed to be 40 km per computer. The VHK methodology adds 1% material for spare parts, which is a good assumption for this kind of products.

3.2.3 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 Figure 5).

EU-15

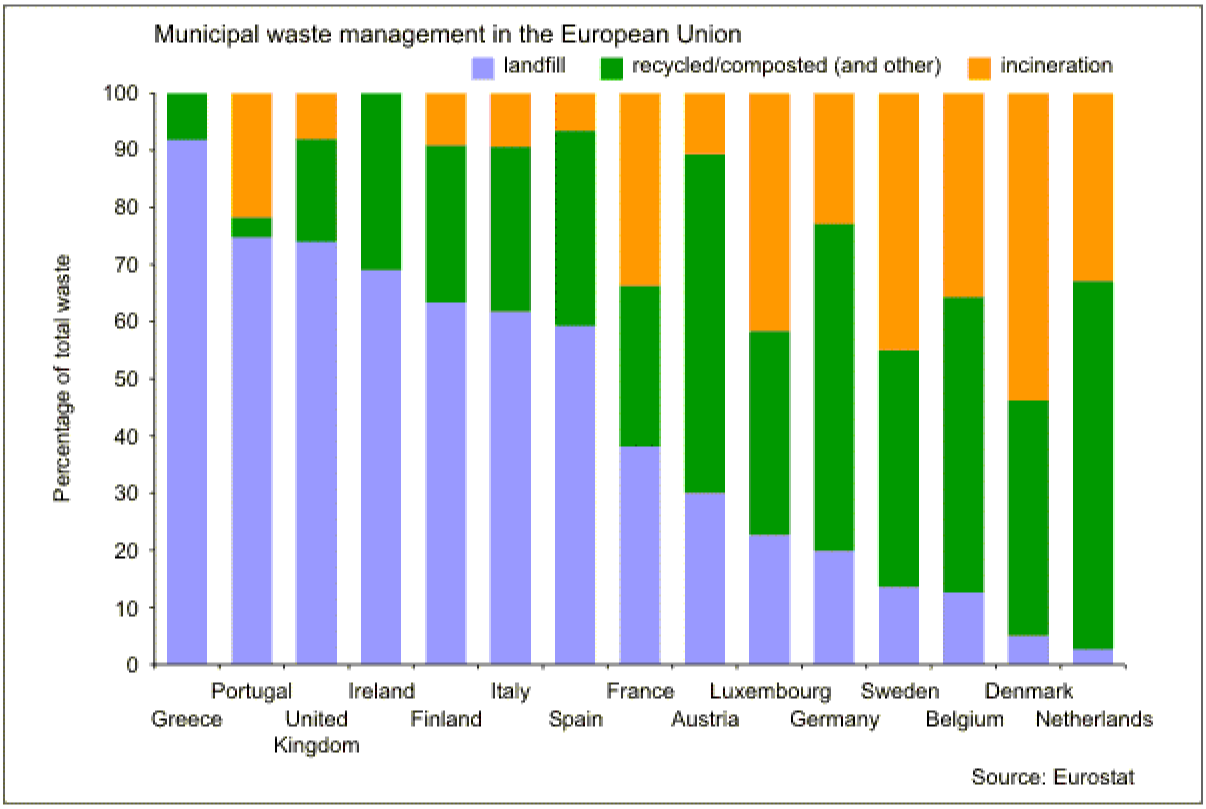

Figure 5 Municipal waste management in the European Union 2003.

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.

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.

3.2.4 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.

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 55 Average total lifetime.

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

3.2.5 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 software's 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.

3.2.5.1 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.

3.2.5.2 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.

3.2.5.3 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.

3.2.5.4 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.

3.2.5.5 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.

3.3 Local infra-structure

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

3.3.1 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.

3.3.2 Internet

3.3.2.1 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 56 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.

3.3.2.2 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 57 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.

3.3.3 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.

3.3.3.1 At 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".

3.3.3.2 At 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".

3.3.3.3 At 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".

3.3.3.4 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.

3.4 References

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- Energy Star energy calculator http://www.eu-energystar.org/calculator.htm
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- European Interactive Advertising Association <http://www,eiaa,net> Women (EIAA)'s Mediascope Europe unit

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- 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

4 Technical analysis existing products

Task 4 consists of a technical analysis of personal computers existing on the EU-market. Bill of materials and resource consumption during all life cycle stages are presented for several product types. This analysis provides general inputs for the definition of base cases in Task 5. The methodology developed by VHK [MEEUP 2005] is followed.

The main computer and monitor manufacturers supplied the data presented. The data collection procedure included: a stakeholder meeting at IVF in Mölndal Sweden 30 May 2006; a questionnaire to stakeholders during summer 2006; feedback to stakeholders in October 2006 and requests for LCA-data; and the stakeholder meeting 20 April 2007 in Brussels. For further information about the data collection, see Appendix 1. Each data set is an average of data from several manufacturers for reasons of confidentiality and also to obtain data representative for the average situation in Europe. The averages cover a large share of the market since they were collected as the best-selling products from the major manufacturers. Originally, six different product types were identified. However, due to lack of data supply, averaged data for four product types are presented. These product types, henceforth referred to as the product cases are:

- Desktop PC, characterized by 3 GHz processor (or equivalent), built-in graphics card, 512 MB RAM and 80 GB HDD
- Laptop, characterized by mobile 1.7 GHz processor (or equivalent), good 3-dimensional graphic performance, 15”-screen, 512 MB RAM and 60 GB HDD
- LCD display, 17”, resolution 1280*1024
- CRT display, 17”.

It should be underlined that the product cases have been chosen on the basis of representing the largest share of the market 2005. Due to non-disclosure-agreements with the data suppliers, it is not possible to give detailed information about each data set used. However, the participant list from the stakeholder meeting in Brussels which includes Fujitsu Siemens, NEC, Sony, AMD, Intel, Mitsubishi, HP, Apple, Toshiba and Dell indicates that most of the major manufacturers have taken part in the process, either directly or through branch organisations like EICTA, AeA or JBCE. The product case data sets cover 6 to 28 % of the market depending on product.

4.1 Production Phase

Preferably, production data should be modularized so that it is possible to distinguish between the contributions from major components. The EPIC report [EPIC-ICT, 2006] shows how a computer can be modularized in a way that is useful for the interpretation of data. This modularization was suggested to the stakeholders in a communication regarding the tentative choice of base cases in October [IVF, October 2006]. The feedback received from the stakeholders, showed that the manufacturers could not deliver data modularized the "EPIC" way. Nevertheless, it is to an extent possible to trace impacts from discrete components. See Task 5.2.

4.1.1 Components and materials assumptions

The production data or bill-of-material is the most difficult part to get right in any life cycle assessment. To obtain data that can be fed into the EuP EcoReport a questionnaire was devised, see questions 15-22 in Appendix 1.

For data not fitting the EcoReport format, assumptions presented in Appendix 1 have been used consistently in the study. The shakiest of these assumptions concerns the approximation of lithium ion batteries with *Big caps and coils.*

Concerning primary scrap production, the default value of 25% proposed in the EcoReport for primary scrap manufacture during sheet metal production was assumed for all products.

4.1.2 Bill of materials, BOM

4.1.2.1 Desktop PCs

Data derived from the summer survey [IVF survey, 2006], shown in the table below, indicate that desktops for the home market varies more in weight, but that the average weight is around 10 kg. The data does not suggest any major differences in the BOM between desktops made for the two markets. The installed base was estimated in Task 2.2.

Table 58 Weights desktop PCs [IVF Summer survey 2006]

	Office desktop	Home desktop
Installed base 2005 in EU 25 (millions)	44	102
Average weight (kg)	9,7	11,7
Min – Max weight (kg)	8,89-11	8,4-14,6

The bill of materials for desktop PCs is shown in the table below. The entries are based on an average of all complete datasets received for office desktops. The bill of materials represents an average of some of the best-selling desktop computers in 2005 and sums up to 10.5 kilograms excluding packaging. See Appendix 1 for more detailed information on data collection.

Table 59 Bill of materials for desktop PCs

EuP Lot 3 prep study: Office desktop PC				MZ
Pos nr	**MATERIALS Extraction & Production Description of component**	**Weight in g**	**Category Click &select**	**Material or Process select Category first !**
1	LDPE	246	1-BlkPlastics	1-LDPE
2	ABS	381	1-BlkPlastics	10-ABS
3	PA 6	138	2-TecPlastics	11-PA 6
4	PC	264	2-TecPlastics	12-PC
5	Epoxy	98	2-TecPlastics	14-Epoxy
6	Flex PUR	2	2-TecPlastics	16-Flex PUR
7	Steel sheet galvanized	6312	3-Ferro	21-St sheet galv.
8	Steel tube/ profile	107	3-Ferro	22-St tube/profile
9	Cast iron	483	3-Ferro	23-Cast iron
10	Ferrite	0	3-Ferro	24-Ferrite
11	Stainless 18/8 coil	10	3-Ferro	25-Stainless 18/8 coil
12	Al sheet/ extrusion	315	4-Non-ferro	26-Al sheet/extrusion
13	Al diecast	15	4-Non-ferro	27-Al diecast
14	Cu winding wire	257	4-Non-ferro	28-Cu winding wire
15	Cu wire	334	4-Non-ferro	29-Cu wire
16	Cu tube/sheet	67	4-Non-ferro	30-Cu tube/sheet
17	Powder coating	2	5-Coating	39-powder coating
18	Big caps & coils	483	6-Electronics	44-big caps & coils
19	Slots /ext. Ports	310	6-Electronics	45-slots / ext. ports
20	Integrated Circuits, 5% Silicon, Au	69	6-Electronics	46-IC's avg., 5% Si, Au
21	Integrated Circuits, 1% Silicon	96	6-Electronics	47-IC's avg., 1% Si
22	SMD & LEDs avg	194	6-Electronics	48-SMD/ LED's avg.
23	PWB ½ lay 3.75 kg/m2	78	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
24	PWB 6 lay 4.5 kg/m2	163	6-Electronics	50-PWB 6 lay 4.5 kg/m2
25	Solder SnAg4Cu0.5	48	6-Electronics	52-Solder SnAg4Cu0.5
26	Cardboard	2287	7-Misc.	56-Cardboard

4.1.2.2 Laptops

Data derived from the summer survey [IVF survey, 2006], shown in the table 60 below, indicate that there are some differences in weight between laptops for the home market and office laptops. The laptop BOM presented below sums up to 2.8 kilogram and is therefore a good representation of both office and home laptops. The installed base was estimated in Task 2.2.

Table 60 Weights laptops [IVF Summer survey 2006].

	Office laptop	**Home laptop**
Installed base 2005 in EU 25 (millions)	36,5	24
Average weight (kg)	2,5	2,9
Min – Max weight (kg)	1,95 - 2,9	2,2-3,6

The battery charger or external power supply that comes as an accessory with every laptop computer is part of the bill of materials. Note that this is an overlap with the preparatory study of external power supplies, Lot 7.

The bill of materials for laptops is shown in the table below. The last entry, *Glass for LCD*, is entered without subcategory. The reason is to avoid double counting of environmental impacts while still accounting for material inputs and maintaining a material balance. Entry 20, *LCD screen m2,* is using the unit 0.001 m2. The bill of materials represents an average of the best-selling laptop computers in 2005 fitted with a 15” LCD-screen and sums up to 2.8 kilograms excluding packaging. See 4.6 for more detailed information on data collection.

Table 61 Bill of materials for laptops.

Nr	Product name	Date	Author
	EuP Lot 3 prep study: Laptops		**MZ**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	LDPE	43	1-BlkPlastics	1-LDPE
2	PP	4	1-BlkPlastics	4-PP
3	PS	3	1-BlkPlastics	5-PS
4	EPS	50	1-BlkPlastics	6-EPS
5	PVC	23	1-BlkPlastics	8-PVC
6	ABS	142	1-BlkPlastics	10-ABS
7	PA 6	281	2-TecPlastics	11-PA 6
8	PC	267	2-TecPlastics	12-PC
9	PMMA	36	2-TecPlastics	13-PMMA
10	Epoxy	3	2-TecPlastics	14-Epoxy
11	Steel sheet galvanized	489	3-Ferro	21-St sheet galv.
12	Al sheet/ extrusion	38	4-Non-ferro	26-Al sheet/extrusion
13				
14	Cu wire	60	4-Non-ferro	29-Cu wire
15	Cu tube/sheet	15	4-Non-ferro	30-Cu tube/sheet
16	MgZn5 cast	122	4-Non-ferro	33-MgZn5 cast
17	Powder coating		5-Coating	39-powder coating
18				
19				
20	LCD screen m2 (viewable screen size)	63	6-Electronics	42-LCD per m2 scrn
21	Big caps & coils	501	6-Electronics	44-big caps & coils
22	Slots /ext. Ports	133	6-Electronics	45-slots / ext. ports
23	Integrated Circuits, 5% Silicon, Au	47	6-Electronics	46-IC's avg., 5% Si, Au
24	Integrated Circuits, 1% Silicon	31	6-Electronics	46-IC's avg., 5% Si, Au
25	SMD & LEDs avg	50	6-Electronics	47-IC's avg., 1% Si
26	PWB ½ lay 3.75 kg/m2	5	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
27	PWB 6 lay 4.5 kg/m2	77	6-Electronics	50-PWB 6 lay 4.5 kg/m2
28	Solder SnAg4Cu0.5	7	6-Electronics	52-Solder SnAg4Cu0.5
29	Glass for lamps	1	7-Misc.	54-Glass for lamps
30	Cardboard	921	7-Misc.	56-Cardboard
31	Glass for LCD	362	7-Misc.	

4.1.2.3 LCD Displays

Industry did not express a need to divide the displays into home and office markets, ie the same displays are sold to both types of customers. However, since displays are used differently in offices compared to homes, it was necessary to collect market data for the two segments. Table 62 below, derived from the summer survey, shows the installed base and weight of 17" LCD-displays. The installed base was estimated in Task 2.2.

Table 62 Weights of LCD-displays [IVF Summer survey 2006].

	Office LCD-display	**Home LCD-display**
Installed base 2005 in EU 25 (millions)	20,5	47,5
Average weight 17" (kg)	6,2	
Average weight per m^2 (kg)	68	
Min – Max weight 17" (kg)	4,0-7,0	

The bill of materials for 17" LCD-displays is shown in the table below. The last entry, *Misc glass*, is entered without subcategory. The reason is to avoid double counting of environmental impacts while still accounting for material inputs and maintaining a material balance. Entry 14, *LCD screen m2,* is using the unit 0.001 m2. The bill of materials represents an average of the best-selling LCD-displays in 2005. See 4.6 for more detailed information on data collection.

Table 63 Bill of materials 17" LCD displays

Pos nr	EuP Lot 3 prep study: LCD displays MATERIALS Extraction & Production Description of component	Weight in g	MZ Category Click &select	Material or Process select Category first !
1	LDPE	164	1-BlkPlastics	1-LDPE
2	EPS	279	1-BlkPlastics	6-EPS
3	PVC	43	1-BlkPlastics	8-PVC
4	ABS	679	1-BlkPlastics	10-ABS
5	PA 6	422	2-TecPlastics	11-PA 6
6	PC	385	2-TecPlastics	12-PC
7	PMMA	153	2-TecPlastics	13-PMMA
8	E-glass fibre	120	2-TecPlastics	18-E-glass fibre
9	Aramid fibre	6,5	2-TecPlastics	19-Aramid fibre
10	Steel sheet galvanized	1854	3-Ferro	21-St sheet galv.
11	Al sheet/ extrusion	39	4-Non-ferro	26-Al sheet/extrusion
12	Cu wire	190	4-Non-ferro	29-Cu wire
13	Powder coating	1,0	5-Coating	39-powder coating
14	LCD screen m2 (viewable screen size)	91	6-Electronics	42-LCD per m2 scrn
15	Big caps & coils	41	6-Electronics	44-big caps & coils
16	Slots /ext. Ports	37	6-Electronics	45-slots / ext. ports
17	Integrated Circuits, 5% Silicon, Au	13	6-Electronics	46-IC's avg., 5% Si, Au
18	Integrated Circuits, 1% Silicon	20	6-Electronics	47-IC's avg., 1% Si
19	SMD & LEDs avg	11	6-Electronics	48-SMD/ LED's avg.
20	PWB ½ lay 3.75 kg/m2	30	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
21	PWB 6 lay 4.5 kg/m2	20	6-Electronics	50-PWB 6 lay 4.5 kg/m2
22	Solder SnAg4Cu0.5	7,6	6-Electronics	52-Solder SnAg4Cu0.5
23	Glass for lamps	26	7-Misc.	54-Glass for lamps
24	Cardboard	650	7-Misc.	56-Cardboard
25	Office paper	55	7-Misc.	57-Office paper
26	Misc glass	308	7-Misc.	
27	Cast iron	1165,0	3-Ferro	23-Cast iron

For monitors two functional units are used, impact per product and impact per screen area as described in Task 1.5.2. Therefore the BOM per m^2 LCD-display is given in the table below.

Table 64 Bill of materials per m² LCD display.

Nr	Product name	Date	Author
	EuP Lot 3 prep study: LCD per m2	**2007-04-27**	**MZ**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	LDPE	1796,3	1-BlkPlastics	**1-LDPE**
2	EPS	3052,6	1-BlkPlastics	**6-EPS**
3	PVC	468,8	1-BlkPlastics	**8-PVC**
4	ABS	7438,1	1-BlkPlastics	**10-ABS**
5	PA 6	4624,5	2-TecPlastics	**11-PA 6**
6	PC	4214,1	2-TecPlastics	**12-PC**
7	PMMA	1674,2	2-TecPlastics	**13-PMMA**
8	E-glass fibre	1311,6	2-TecPlastics	**18-E-glass fibre**
9	Aramid fibre	71,2	2-TecPlastics	**19-Aramid fibre**
10	Steel sheet galvanized	20304,9	3-Ferro	**21-St sheet galv.**
11	Cast iron	12761,5	3-Ferro	**23-Cast iron**
12	Al sheet/ extrusion	425,4	4-Non-ferro	**26-Al sheet/extrusion**
13	Cu wire	2076,7	4-Non-ferro	**29-Cu wire**
14	Powder coating	11,3	5-Coating	**39-powder coating**
15	LCD screen m2 (viewable screen size)	1000,0	6-Electronics	**42-LCD per m2 scrn**
16	Big caps & coils	452,9	6-Electronics	**44-big caps & coils**
17	Slots /ext. Ports	400,3	6-Electronics	**45-slots / ext. ports**
18	Integrated Circuits, 5% Silicon, Au	140,7	6-Electronics	**46-IC's avg., 5% Si, Au**
19	Integrated Circuits, 1% Silicon	222,9	6-Electronics	**47-IC's avg., 1% Si**
20	SMD & LEDs avg	117,2	6-Electronics	**48-SMD/ LED's avg.**
21	PWB ½ lay 3.75 kg/m2	328,6	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
22	PWB 6 lay 4.5 kg/m2	214,7	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
23	Solder SnAg4Cu0.5	82,7	6-Electronics	**52-Solder SnAg4Cu0.5**
24	Glass for lamps	284,8	7-Misc.	**54-Glass for lamps**
25	Cardboard	7119,4	7-Misc.	**56-Cardboard**
26	Office paper	596,9	7-Misc.	**57-Office paper**
27	Misc glass	3369,1	7-Misc.	

4.1.2.4 CRT Displays

Industry did not express a need to divide the displays into home and office markets, ie the same displays are sold to both types of customers. However, since displays are used differently in offices compared to homes, it was necessary to collect market data for the two segments. The table, derived from the summer survey, shows the installed base and weight of 17" CRT-displays[1]. The installed base was estimated in Task 2.2.

[1] The reason for chosing CRT-screen size 17" is that it represents the most sold screen 2005. In actual view size it is smaller and not comparable to a 17" LCD-screen.

Table 65 Weight of CRT displays

	Office CRT-display	Home CRT-display
Installed base 2005 in EU 25 (millions)	24	57
Average weight 17" (kg)	16,2	
Weight per m^2 (kg)	180	
Min – Max weight 17" (kg)	15,0-17,5	

The bill of materials for CRT-displays is shown in the table below. The last entry, *Misc glass*, is entered without subcategory. The reason is to avoid double counting of environmental impacts from the glass in the CRT while still accounting for material inputs and maintaining a material balance. Entry 10, *CRT screen m^2*, is using the unit 0.001 m^2. The bill of materials represents an average of the best-selling CRT-displays in 2005. See 4.6 for more detailed information on data collection.

Table 66 Bill of materials 17" CRT Displays.

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	EPS	165	1-BlkPlastics	6-EPS
2	PVC	44	1-BlkPlastics	8-PVC
3	ABS	1755	1-BlkPlastics	10-ABS
4	PA 6	447	2-TecPlastics	11-PA 6
5	PC	0,6	2-TecPlastics	12-PC
6	Steel sheet galvanized	126	3-Ferro	21-St sheet galv.
7	Al sheet/ extrusion	14	4-Non-ferro	26-Al sheet/extrusion
8	Cu wire	222	4-Non-ferro	29-Cu wire
9	Powder coating	6,0	5-Coating	39-powder coating
10	CRT screen m2 (nominal screen size)	90	6-Electronics	43-CRT per m2 scrn
11	Big caps & coils	38	6-Electronics	44-big caps & coils
12	Slots /ext. Ports	40	6-Electronics	45-slots / ext. ports
13	Integrated Circuits, 5% Silicon, Au	17	6-Electronics	46-IC's avg., 5% Si, Au
14	Integrated Circuits, 1% Silicon	14	6-Electronics	47-IC's avg., 1% Si
15	SMD & LEDs avg	13	6-Electronics	48-SMD/ LED's avg.
16	PWB ½ lay 3.75 kg/m2	96	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
17	PWB 6 lay 4.5 kg/m2	24	6-Electronics	50-PWB 6 lay 4.5 kg/m2
18	Solder SnAg4Cu0.5	11	6-Electronics	52-Solder SnAg4Cu0.5
19	Glass for lamps	6,5	7-Misc.	54-Glass for lamps
20	Cardboard	1880	7-Misc.	56-Cardboard
21	Office paper	280	7-Misc.	57-Office paper
22	Misc glass	11110	7-Misc.	

For monitors two functional units are used, impact per product and impact per screen area, as described in Task 1.5.2. Therefore the BOM per m^2 CRT-display is given in the table below.

Table 67 Bill of materials per m² CRT Display.

Nr	Product name	Date	Author
	EuP Lot 3 prep study: CRT per m2	**2007-06-11**	**MZ**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	EPS	1829,3	1-BlkPlastics	**6-EPS**
2	PVC	485,6	1-BlkPlastics	**8-PVC**
3	ABS	19454,0	1-BlkPlastics	**10-ABS**
4	PA 6	4960,9	2-TecPlastics	**11-PA 6**
5	PC	6,1	2-TecPlastics	**12-PC**
6	Steel sheet galvanized	1396,9	3-Ferro	**21-St sheet galv.**
7	Al sheet/ extrusion	155,2	4-Non-ferro	**26-Al sheet/extrusion**
8	Cu wire	2463,4	4-Non-ferro	**29-Cu wire**
9	Powder coating	66,9	5-Coating	**39-powder coating**
10	CRT screen m2 (nominal screen size)	1000,0	6-Electronics	**43-CRT per m2 scrn**
11	Big caps & coils	415,7	6-Electronics	**44-big caps & coils**
12	Slots /ext. Ports	443,5	6-Electronics	**45-slots / ext. ports**
13	Integrated Circuits, 5% Silicon, Au	188,5	6-Electronics	**46-IC's avg., 5% Si, Au**
14	Integrated Circuits, 1% Silicon	149,7	6-Electronics	**47-IC's avg., 1% Si**
15	SMD & LEDs avg	138,6	6-Electronics	**48-SMD/ LED's avg.**
16	PWB ½ lay 3.75 kg/m2	1064,3	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
17	PWB 6 lay 4.5 kg/m2	260,5	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
18	Solder SnAg4Cu0.5	122,0	6-Electronics	**52-Solder SnAg4Cu0.5**
19	Glass for lamps	72,1	7-Misc.	**54-Glass for lamps**
20	Cardboard	20842,6	7-Misc.	**56-Cardboard**
21	Office paper	3104,2	7-Misc.	**57-Office paper**
22	Misc glass	123165,2	7-Misc.	

4.2 Distribution phase

The distribution phase is (in the EcoReport) assumed to be proportional to the volume of packaged final product in m³. This volume was assessed by question 9 in Appendix 1. The entries, which are averages of all complete datasets received and used in respective product case, are shown in the table below.

Distribution to Europe is also dependant on where in the world the product is manufactured. To account for a lot of smaller size electronics being manufactured in Asia, the question: *Is it an ICT or consumer electronics <15 kg?*, has to be answered in the EcoReport. This question was answered with YES for all product cases. A CRT actually weighs more than 15 kg, but most CRTs are today being produced in Asia.

Table 68 Volume of packaged product.

Product case	Volume of packaged product[2] (m^3)	Volume per m^2 packaged product[2] (m^3/m^2)
Desktop	0,09	NA
Laptop	0,02	NA
LCD-display	0,04	0,438
CRT-display	0,1	1,11

4.3 Use phase (product)

Since there is no test standard that takes into account the use profile of personal computers, it is not possible to assess life-cycle impacts of PCs in standard conditions. Only the real-life base-cases according to the VHK-method [MEEUP 2005] can be assessed. However, the Energy Star programme criteria are used as much as possible to ensure that the input data for the calculations is representative.

4.3.1 Electricity measurements - computers

Measuring computers' electricity use is problematic in three ways:

- The terminology is confusing
- Energy Star's idle measurement method was just recently defined
- There is no agreed method to measure when the computer is actually working

In this section is described how the study has dealt with these problems.

The terminology

The terminology used for computers' different operational modes is confusing. The EuP EcoReport states three "energy modes": On, stand-by and off. In Energy Star version 4.0, the corresponding modes are: idle, sleep and off/stand-by, see task 1.3. In this study terms and definitions will as much as possible follow Energy Star version 4.0, see the table below.

Table 69 Operational modes for personal computers.

Energy Star version 3.0	EuP EcoReport	Energy Star version 4.0	Terminology used in this study
Not measured	On	Idle	Idle
Sleep	Stand-by	Sleep (ACPI S3)	Sleep
Not measured	Off	Standby level (Off Mode) (ACPI S4 or S5)	Off[3]

[2] Averages of all complete datasets received and used in respective product case.

[3] So called soft off ie the pc is still plugged in.

Idle measurements

The major difference between the old (but still in use) Energy Star version 3.0 and the new 4.0 is that 4.0 requires measurement (and comparing with threshold limit values) of all the three modes: idle, sleep and off. With version 3.0, only the sleep mode was measured. Consequently, version 4.0 includes a test procedure that defines how the computer should enter the different operational modes and the duration of each measurement.

During 2005, before Energy Star 4.0 was available, it was more common to test for "Operational Mode" which has the following loose definition: "For PCs, this generally correlates with the ACPI S0 power consumption state. i.e. PC hard disk drive (HDD) operating, Operating System active with desktop displayed, but no other devices (drives) or software applications running". According to one producer ACPI S0 would “roughly” approximate idle power consumption for his PCs, although, there are slight differences in the definitions used. The Energy Star 4.0 "Idle State" definition is as follows: "For purposes of testing and qualifying computers under this specification, this is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default." So, the definitions are close to one another but are not exact. Therefore, these values should not be taken as 100% accurate for Energy Star 4.0 idle, but as approximations.

Because this study took place while the new Energy Star test method was being developed, not all data was derived using the new method. The possible error due to this is estimated to plus or minus 10% on the power values.

Measures of performance

As described above, the computer is not performing any work when in idle mode. The power use during work can be anything from the same (thinking about what to write) to a lot more (playing a sophisticated computer game with lots of graphics) than idle mode power. ECMA have a working group aiming at developing a universally accepted test method where energy consumption can be measured against computer performance. However, the working group has recently started, and aims at finishing their work late 2007. Their results can therefore not be used in this preparatory study [ECMA 2006].

In this study, the idle power value is used as an indicator for when the computer is active; either ready to do work or doing work. We know that the idle indicator is a minimum value for the “active” mode, but we do not know how much larger the true average work power value is. One recent study [Monitoring home computers, 2006] suggest that the difference is very small. Also the time estimations for the different operational modes is a source of error, see task 3. Since the energy consumption is calculated as power multiplied by time, these two error sources can be examined together. The possible error due to these two error sources is estimated to minus 50% to plus 100% on the energy consumption values. What this means to the robustness of the results is examined by sensitivity calculations in Task 8.

Only data about power consumption in the idle, sleep and off modes were asked from the manufacturers when requesting data, see questions 11-13 in Appendix 1, because only these modes are supported by test standards as explained above. In the usage pattern study, Task 3, there is no differentiation between time spent in idle and active modes – both are referred as "active" mode in that task.

4.3.2 Electricity measurements - monitors

Computer monitors use most power in on-mode. The notion that the resolution is linked to the power consumption is not true for many types of monitors, including LCD. The screen size is much more correlated to the power consumption because of the way a LCD monitor brings the picture to the screen. The notion that the energy use correlates to the resolution [Megapixels] stems from when the standard was a plasma screen where each pixel element is an individual light source that is illuminated as needed. LCD, on the other hand, always has a backlight running, and rather than lighting up pixels, an LCD monitor will BLOCK them, so the light doesn't get through. Whether the grid of liquid crystal is made of many small elements as for a high-resolution screen or fewer larger elements as for a low-resolution screen will almost not affect the power consumption of the display. More than 90% of the power consumption in a LCD monitor relates to the backlight. That means that the power consumption for LCD screens is relatively independent of the resolution in the liquid crystal filter in front of the backlight. For CRT monitors the power consumption is also depending on the screen size, as the electron beam has to activate a larger area of phosphorous for a larger screen. It is therefore natural that we can see a correlation between screen size and power consumption also for CRT monitors. For new technologies such as LED backlight, the correlation is that the larger the screen, the more energy it will use, caused by either higher number of lamps, or bigger lamps using more energy.

Statistics from TCO

TCO Development has made some research on this subject a few years ago and the result clearly shows that the resolution on the screen has a very little influence on the power consumption while the screen size shows an almost linear correlation. This research has been conducted at a third party test laboratory called Intertek Semko in Sweden.

A large amount of LCD monitors was measured according to the TCO standard. Also CRT monitors were tested. The results were presented in the two graphs with the power consumption versus screen size shown below.

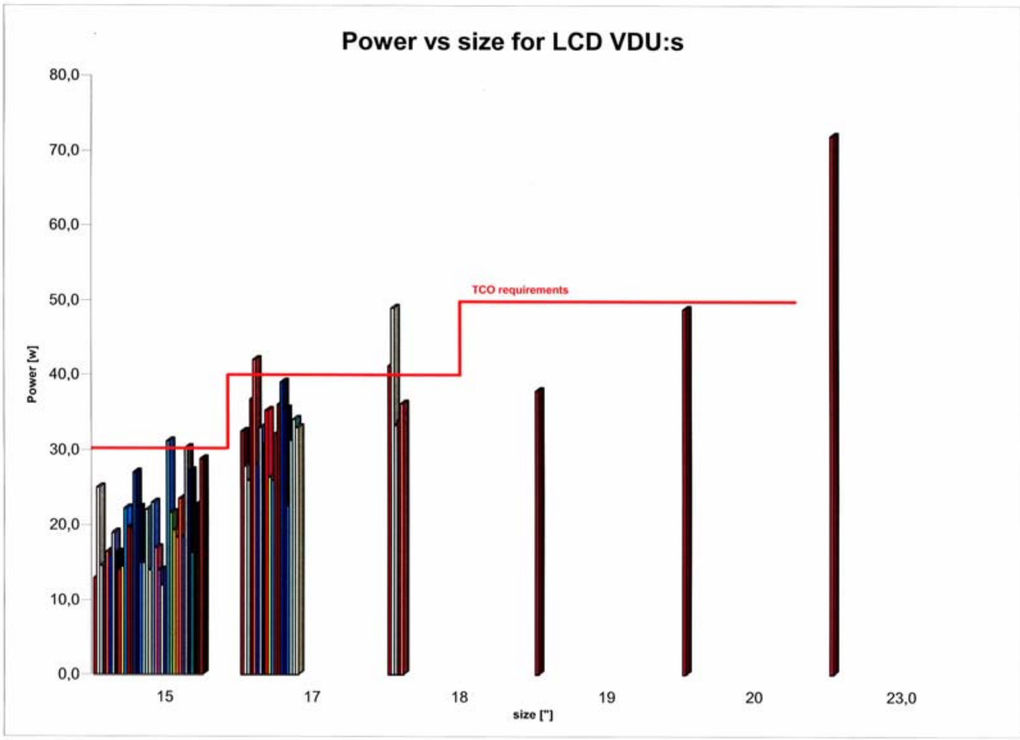

Figure 6 Power versus size for LCD from TCO study 2003

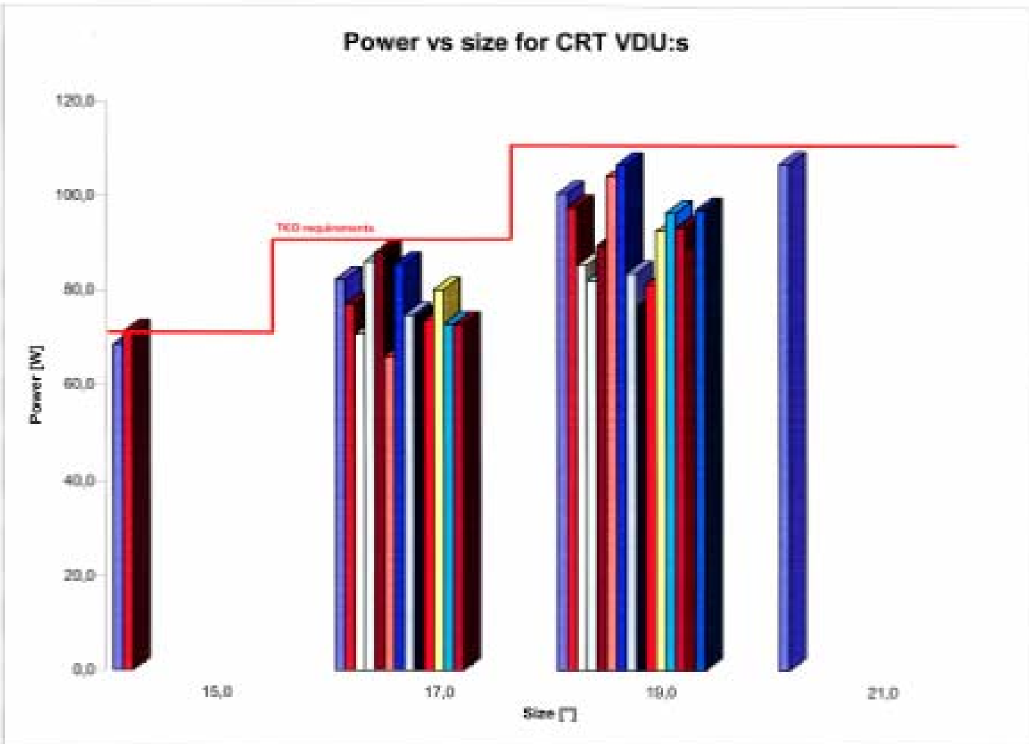

Figure 7 Power versus size for CRT, from TCO study, 2003

To compare these results with the theory that the resolution should have any influence on the power consumption a second study was made. Here 3 monitors were measured in 5 different resolutions. The graph also shows the allowed energy consumption according to Energy Star limits. It can be seen that it becomes unnaturally high at high resolutions.

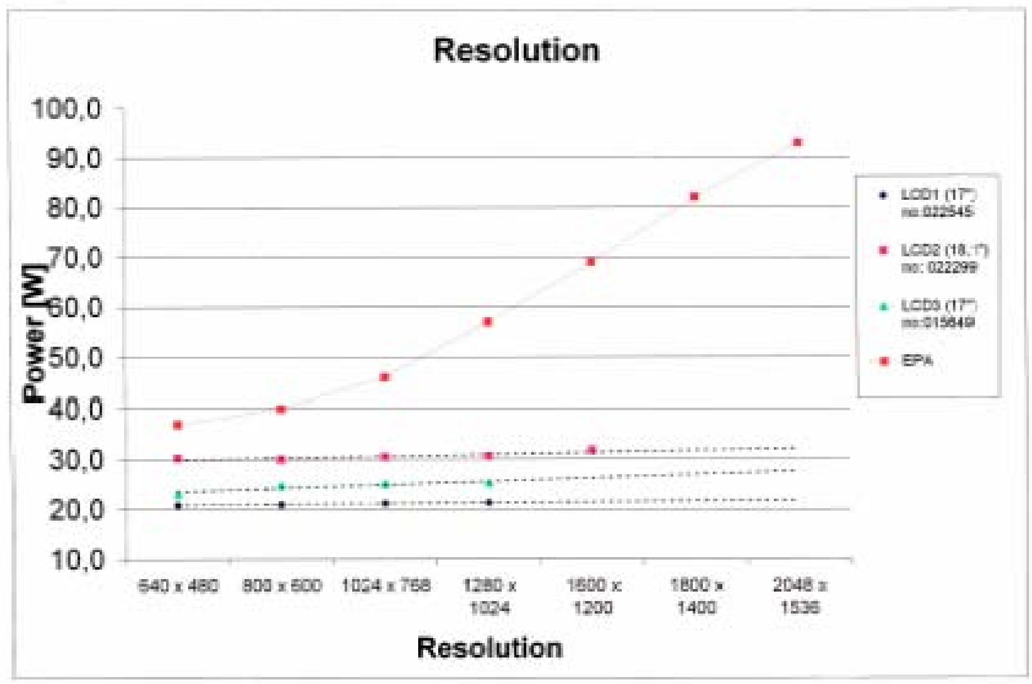

Figure 8 Power versus resolution, from TCO study 2003

To further develop this discussion one can reflect over the fast development of notebook computers. The screen size has been stalled at a maximum of around 15” due to the fact that the notebook shall be portable. However, the maximum resolution has been increased from 800 x 600 a few years ago up to 1680 x 1050 and the power consumption has not increased.

At the same time we have LCD TVs, which do not need any high resolutions as the HDTV is not used in many countries and the resolution for a DVD movie is only 720×576. LCD TV’s are often very big, more than 32”, and it is totally impossible for them to have the same power consumption as a 15” computer display even if the resolution may even be lower than for the 15” display.

A large display requires a lot of lamps in the back light to have a uniform luminance distribution. Every extra inch in size will require more light and every extra lamp will consume more power. There are both big displays with high resolution and low resolution and they consume the same power. The resolution can but does not naturally follow the screen size. The resolution needed is dependant on the display is supposed to be used for. For example, large screens for long distanses, such as for media computer screens and airport information, can have a low resolution, and small screens for photo editing needs a high resolution.

Statistics from Energy Star

Based on statistics from Energy Star database 2007, the following pictures can be seen. To be noted is that only monitors fulfilling the requirements of Energy Star (4.1) where the on-mode power has to be lower than 38*(number of megapixels)+30 W. This means that large screens with low resolution cannot comply, and they are therefore not part of the statistics!

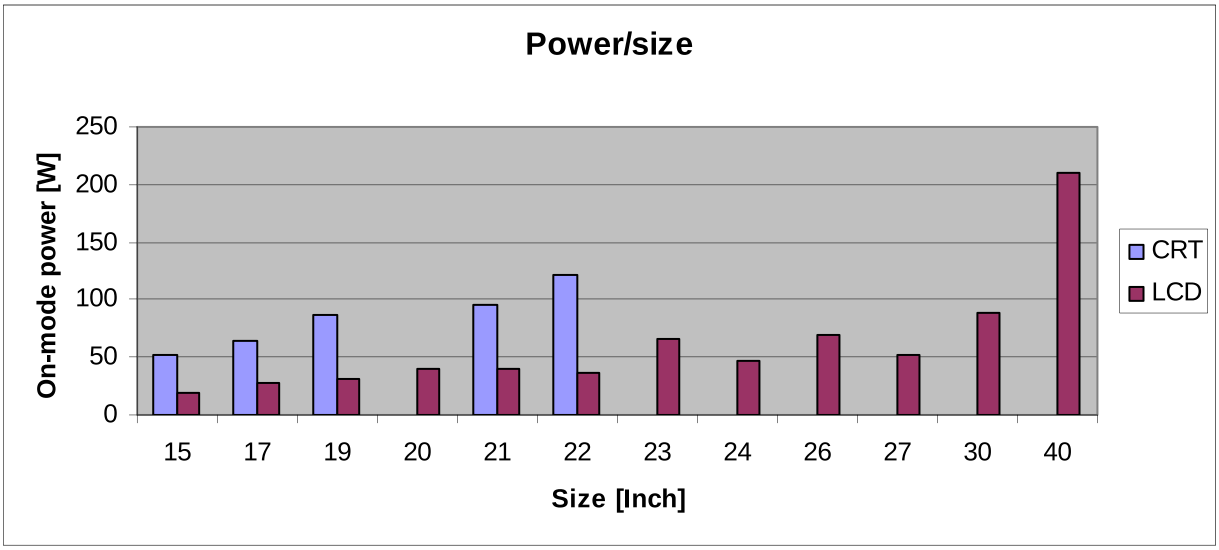

Figure 9 Power versus size, from Energy Star database 2007

When calculating the “true” screen area, including the differences due to the different relations between width and height for the products in the Energy Star database, we get the following graph:

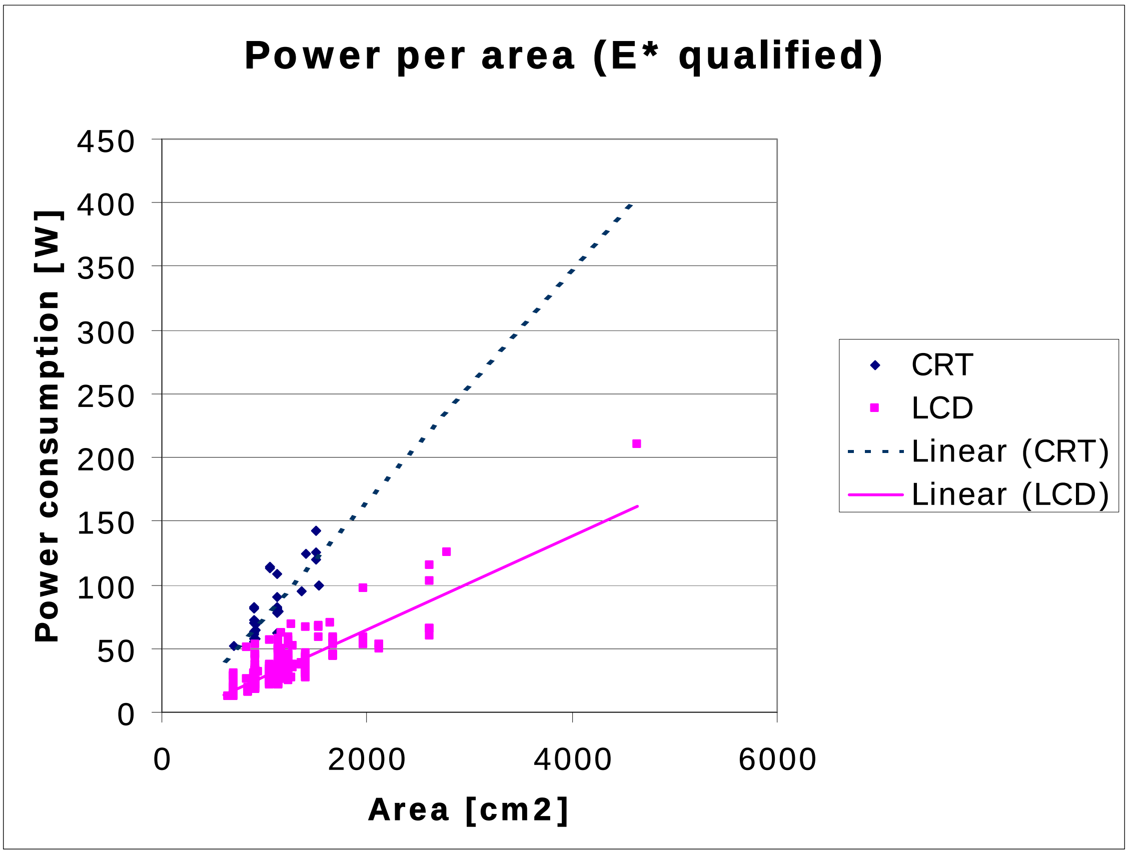

Figure 10 On-mode power versus true screen area from Energy Star database 2007

Here we can se a strong relationship between the power consumption in on-mode and the area of the monitors. The correlation coefficient is above 0.8.

Another graph from the same sample, where we use power consumption versus Megapixels, shows less relationship. The correlation coefficient is only 0.51 for LCD screens.

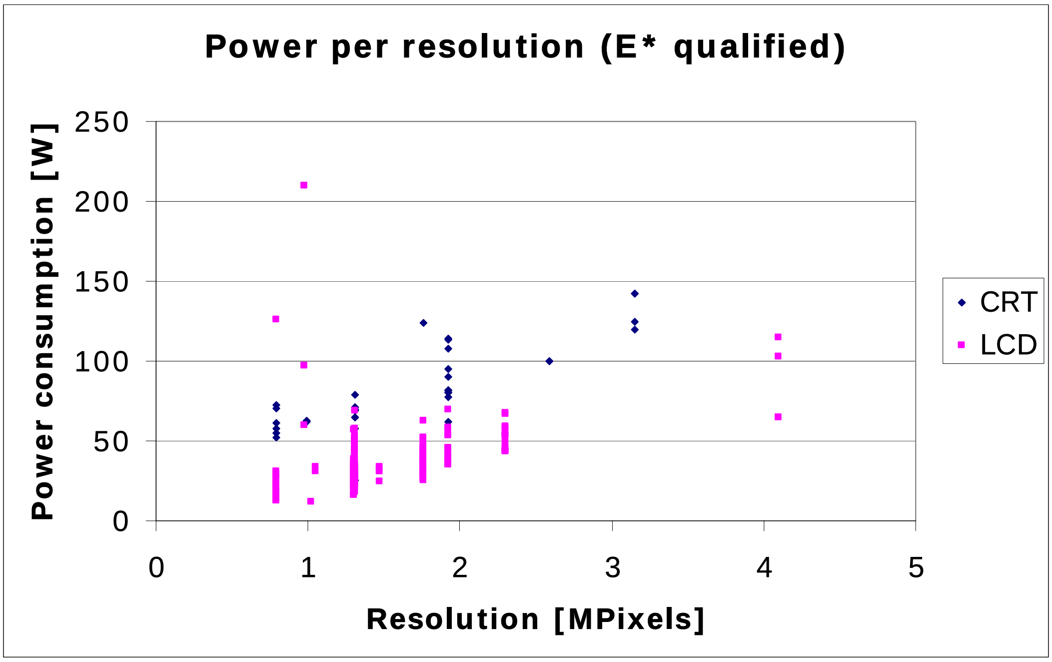

Figure 11 On-mode power resolution area from Energy Star database 2007

The correlation coefficient for the graphs is described in the table below:

Table 70 Correlation coefficient for power consumption versus resolution and area respectively

	Power consumption	
	CRT	LCD
Resolution	0,8210	0,5064
Area	0,8078	0,8174

This shows that the correlation is much higher between the power consumption and the area than between the power consumption and the resolution, especially for LCD. If the large monitors not qualifying for Energy Star would have been a part of the sample, the correlation between resolution and power in on-mode would have been even less.

From the Energy Star statistics we get the following values for max, average and min power in on-mode per m^2 and per Megapixel (MPx).

Table 71 Power in on-mode for monitors according to Energy Star statistics

	Power [W/m2]		Power [W/MPx]	
	CRT	LCD	CRT	LCD
Max	1087	617	92	214
Average	760	290	52	23
min	281	184	20	12

Statistics from IVF survey

The data coming from surveys within the Eup Lot 3 study gives the following information. Data is measured according either to manufacturers internal measuring methods or according to Energy Star measuring methods.

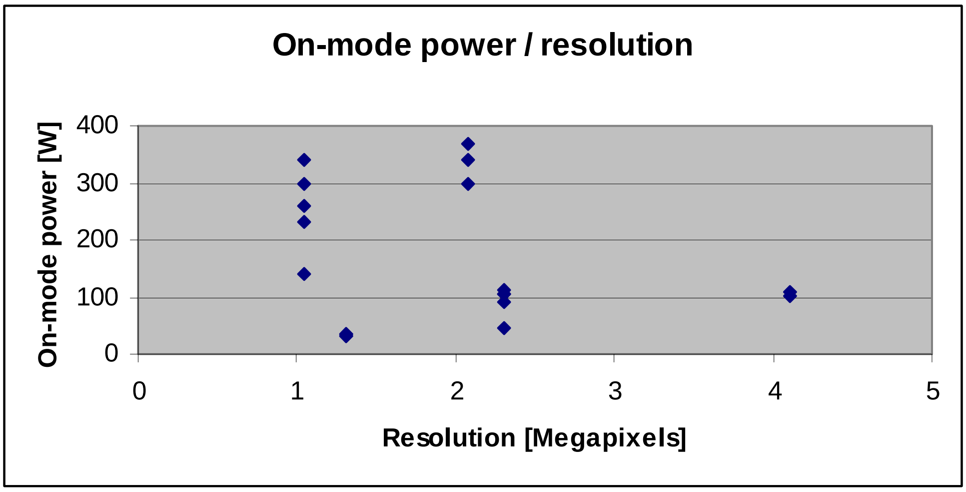

Figure 12 On-mode power per resolution from IVF survey

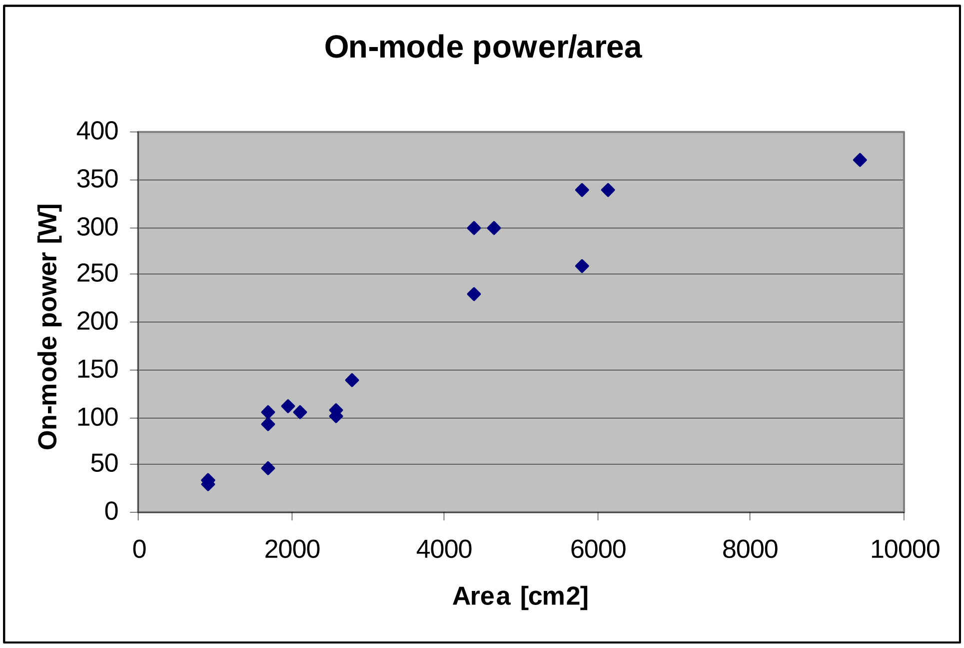

Figure 13 On-mode power per area from IVF survey (including large monitors)

The data collected by the study support the idea that power consumption is related to the area of a computer monitors.

Measurement methods

Regarding available measurement methods, the method used by Energy Star is well established in the industry and the test procedure is considered good. The measuring method can be used to measure power consumption per area as well as power consumption per resolution or per product. However, there is sometimes a problem regarding repeatability for measurement of computer monitors. In the procedure it is stated that the testing shall be done at a certain luminance setting. To arrive at this setting the test engineer has to adjust the brightness and contrast settings of the computer monitor according to the instructions. At one point the test engineer has to make a perceptual evaluation of a grey scale to see whether all of the different grey levels are visible or not. At this point different engineers may have different interpretations of what is visible as a grey level and this will affect the settings of the monitor during the test and thus the result of the testing.

One solution to this problem would be to let the test engineer use a luminance meter and measure the difference between the grey levels. The standard could state that the levels are considered to be different if the luminance differ more than 5 cd/m^2 between two levels. In this way the repeatability of the test method would be improved.

4.3.3 Repair, service and maintenance

Repairs are fixed at 1% extra material over the life cycle in the EuP EcoReport. Interviews with computer repair shops and Information Technology Managers indicate that an average PC repair cost could amount to 125 Euro for computers, see Task 2. LCD-displays and CRT-displays are normally no longer repaired at all according to TCO [2007].

Assuming that repair transports are local and happens on average once for all units that needs repairing, a transport distance of 40 km has been inserted in the EcoReport for computers. Since a shorter service life is assumed for laptops (5.6 years) than for desktops (6.6 years), laptops are the most service intensive products.

4.3.4 Electricity per product case - computers

This section describes the data collection for deciding the electricity use in the use phase for the computer base cases. The figures, which are presented in the table below, are selected to represent an average computer in 2005 and are solely to be used for the analysis in the preceding tasks. The values do in no way infer suggestions for minimum requirements or any other implementing measure.

Table 72 Power figures selected for the base cases.

Product cases / Operational modes	Desktop	Laptop
Idle (Watt)	78,2	32[4]
Sleep (Watt)	2,2	3
Off (Watt)	2,7	1,5

The figures in the table above are drawn in the figure below.

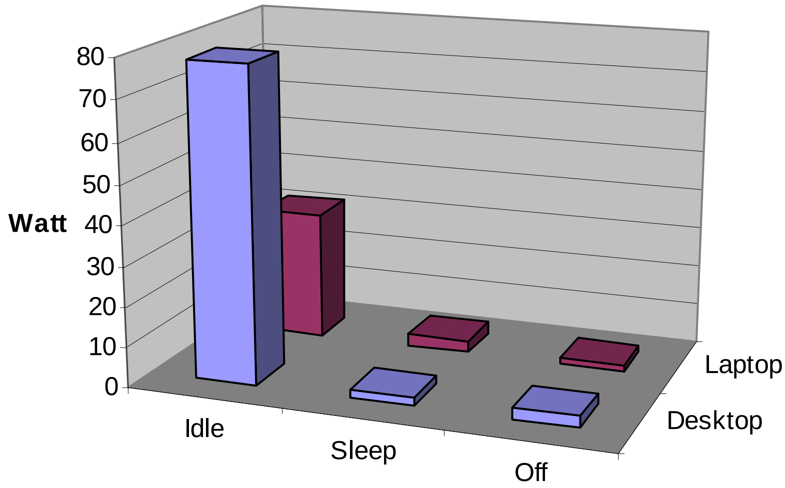

Figure 14 Power figures for laptops and desktops

4.3.4.1 Desktop PCs

In the table below, data from the product case data sets are compared with data from the IVF summer survey and data from Energy Star. Both in the summer survey and for the product case data sets, data representing the best-selling computers in 2005 were asked for from all the major manufacturers. The number of individual computers/data sets is less in the product case, but the product case data sets are much more complete as they also contain bill of materials.

The summer survey data indicate that desktops for the home market have a lower but more varied idle power than office desktops. A plausible explanation is that desktops have more varied uses (and therefore specifications) in the home compared to the office.

The Energy Star data comprises almost all desktops (more than 100 different models) on the market 2006, ie a year later. Note that the Energy Star data is not representing the best-selling computer. Approximately 10% of desktops in the Energy Star data are integrated computers. However, the market share of integrated computers is estimated to less than 2%. Including or not including the

[4] Screen on. The only available idle mode test standard, in Energy Star 4.0, specifies testing with screen off. The figure 32,0 includes 10 Watt for the LCD-screen.

integrated computers in the Energy Star averages does not change the figure significantly.

Table 73 Desktop power

Data sources / ***Operational modes***	**IVF summer survey**		**Product case data sets**[5]	**Energy Star 2006 data**
	Office desktop	**Home desktop**		
Idle, Average (min – max) (Watt)	73,8 (70,5-78)	61 (50-79,7)	78,2	81,7 (221-23)
Sleep, Average (min – max) (Watt)	3,3 (1,2 - 4,2)	3,7 (2,61-5)	2,2	3,1 (1,4-10,1)
Off, Average (Watt)	1,4 (1 – 2,3)	1,4 (0,7-3)	2,7	2,0 (0,4-10,1)

The figures from the IVF summer survey and the Energy Star figures indicate that the product case figures 78.2 Watt, 2.2 Watt and 2.7 Watt constitute balanced estimates for the average 2005 desktop computer. These are the figures used in the calculations. The summer survey results indicate lower values (especially for home desktops), but the existence of a considerable white box market segment and also high-end computers, motivate using the Product case figures for the calculations. The possible error should be well within plus or minus 10%.

In the data set chosen for the base cases, sleep power is lower than off power. This is not common, but does happen. Approximately 10% of the computers in the Energy Star 2006 database show the same pattern. In the figure below it is shown that the sleep and off values have no influence on the use phase life cycle electricity consumption.

[5] Average of all complete data sets received for this product case.

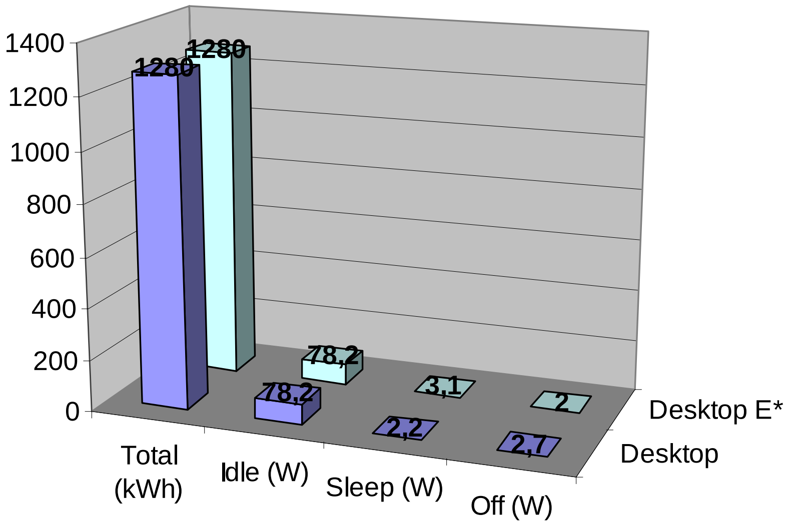

Figure 15 Life cycle electricity consumption for (office) desktops calculated with different values for sleep and off

Since the unusual values for sleep and off do not influence the life cycle electricity consumption, the product case data set is chosen for the base cases since this data set also contain the bill of materials.

The use phase entries for desktop PCs used in offices are shown in the table below. The energy entries are based *on an average of all complete datasets* received for desktops, see Product case in the table above. The time related entries are based on Task 3.2.4.

Table 74 Use phase entries for desktops used in offices.

Description	**Value**	**Unit**	**Yearly [kWh]**
Product Life in years	**6,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0782	KWh	178,2178
Idle-mode: No. Of hours, cycles, settings, etc. / year	2279	#	
Sleep-mode: Consumption per hour	0,0022	KWh	7,0312
Sleep-mode: No. Of hours / year	3196	#	
Off-mode: Consumption per hour	0,0027	KWh	8,8695
Off-mode: No. Of hours / year	3285	#	
TOTAL over Product Life	**1,28**	**MWh**	
Maintenance, Repairs, Service			
No. of km over Product-Life	40	Km	
Spare parts (fixed, 1% of product materials & manuf.)	68	G	

The use phase entries for desktop PCs used in *homes* are shown in the table below. The energy entries are based *on an average of all complete datasets* received for desktops, see Product case in the table above. The time related entries are based on Task 3.2.4.

Table 75 Use phase entries for desktops used in homes.

Description	**Value**	**Unit**	**Yearly [kWh]**
Product Life in years	**6,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0782	kWh	123,7124
Idle-mode: No. Of hours, cycles, settings, etc. / year	1582	#	
Sleep-mode: Consumption per hour	0,0022	kWh	6,3206
Sleep-mode: No. Of hours / year	2873	#	
Off-mode: Consumption per hour	0,0027	kWh	11,6235
Off-mode: No. Of hours / year	4305	#	
TOTAL over Product Life	**0,93**	**MWh**	
Maintenance, Repairs, Service			
No. of km over Product-Life	40	km	
Spare parts (fixed, 1% of product materials & manuf.)	68	g	

4.3.4.2 Laptops

In the table below, data from the product case data sets are compared with data from the IVF summer survey and data from Energy Star. Both in the summer survey and for the product case data sets, data representing the best-selling computers in 2005 were asked for. The number of individual computers is less in the product case.

The Energy Star data comprises almost all laptops (just under 100 different models) on the market 2006, ie a year later. Note that the Energy Star data is not representing the best-selling computer.

Table 76 Laptop power consumption.

Data sources	**IVF summer survey**		**Product case data sets**[6]	**Energy Star 2006 data**
Operational modes	**Office laptop**	**Home laptop**		
Idle, Average (min – max) (Watt)	25,7 (18-34,6)	22,6 (17-34,2)	22,0	19,5 (6,8-38,1)
Sleep, Average (min – max) (Watt)	3,2 (1,7-7,7)	2,3 (0,5-5,0)	4,9	1,4 (0,3-3,5)
Off, Average (Watt)	1,6 (0,3-3)	1,4 (0,28-3)	1,2	0,9 (0,1-2,4)

The figures from the IVF summer survey and the Energy Star figures indicate that the product case figures 22.0 Watt, 4.9 Watt and 1.2 Watt constitute balanced estimates for the average 2005 laptop. However, the idle value has to be adjusted because laptops are tested with the screen off. Estimates from one producer

[6] Average of all complete data sets received for this product case.

stating that the screen takes 30% of the total energy consumed, would mean adding 9.4 Watts to the 22 Watts. TCO tests in 2005, gives an average of 16.4 Watts for 15" LCD-displays. The 16.4 Watt figure include power supply losses and screens in laptops are, according to TCO, more energy optimized than screens in LCD-displays, so the figures correspond well. 10 Watt is added to the 22 Watt idle power figure. The sleep and off mode values are also adjusted to better reflect the results of the summer survey, which had a larger sample.

Table 77 Laptop adjusted power consumption.

Product case data sets adjusted	
Idle, Average (Watt)	32
Sleep, Average (Watt)	3
Off, Average (Watt)	1,5

The figures in the above table are used in the calculations. As stated in 4.3.1, the possible error should be well within plus or minus 10%. All the use phase entries for Laptops used in offices are shown in the table below. The time related entries are based on the Task 3.

Table 78 Use phase entries for laptops used in offices.

Description	**Value**	**Unit**	**Yearly [kWh]**
Product Life in years	**5,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,032	kWh	83,616
Idle-mode: No. Of hours, cycles, settings, etc. / year	2613	#	
Sleep-mode: Consumption per hour	0,003	kWh	8,985
Sleep-mode: No. Of hours / year	2995	#	
Off-mode: Consumption per hour	0,0015	kWh	4,7295
Off-mode: No. Of hours / year	3153	#	
TOTAL over Product Life	**0,55**	**MWh**	
Maintenance, Repairs, Service			
No. of km over Product-Life	40	km	
Spare parts (fixed, 1% of product materials & manuf.)	38	g	

Laptops are sometimes off and unplugged. In this mode they do not consume any energy at all. Assuming that 10% of the off-mode is unplugged, the yearly or life cycle electricity consumption would decrease with 0.5%. This negligible influence is not modelled, but considered in the sensitivity calculations.

The use phase entries for laptops used in *homes* are shown in the table below. The power entries are based on the discussion above, see Table 77. The time related entries are based on the Task 3.

Table 79 Use phase entries for laptops used in homes.

Description	Value	Unit	Yearly [kWh]
Product Life in years	**5,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,032	kWh	44,416
Idle-mode: No. Of hours, cycles, settings, etc. / year	1388	#	
Sleep-mode: Consumption per hour	0,003	kWh	8,712
Sleep-mode: No. Of hours / year	2904	#	
Off-mode: Consumption per hour	0,0015	kWh	6,702
Off-mode: No. Of hours / year	4468	#	
TOTAL over Product Life	**0,34**	**MWh**	
Maintenance, Repairs, Service			
No. of km over Product-Life	40	km	
Spare parts (fixed, 1% of product materials & manuf.)	68	g	

It should be noted that the power losses in the battery charger or external power supply is included in the power figures for laptop computers. Battery chargers and external power supplies, relevant for laptops, are covered also by a separate study, lot 7, ie there is an overlap with the lot 7 study in this area. This is further discussed in Task 5.

4.3.5 Electricity per product case - monitors

This section describes the data collection for deciding the electricity use in the use phase for the monitor base cases. The figures, which are presented in the table below, are selected to represent an average monitor in 2005 and are solely to be used for the analysis in the preceding tasks. The values do in no way infer suggestions for minimum requirements or any other implementing measure.

Table 80 Power figures selected for the base cases.

Product cases / ***Operational modes***	**LCD-screen per m^2**	**CRT-screen per m^2**	**LCD-screen 17"**	**CRT-screen 17"**
Active (Watt)	345	771	31.4	69.5
Sleep (Watt)	10.3	16,6	0.9	1.5
Off (Watt)	9.2	16,6	0.8	1.5

Please see task 4.3.2 for a discussion of the different functional units.

4.3.5.1 LCD-displays

In the table below, data from the product case data sets are compared with data derived from the summer survey and data from TCO. Both in the summer survey and for the product case data sets, data representing the best-selling LCD-displays in 2005 were asked for. The number of individual displays is less in the product case. The TCO data, comprising around 100 different 17" LCD-display models, has no correlation to market share.

The reason for that the sleep and off values are almost identical is that for most models, this is today technically the same mode.

The reason for the TCO active mode figures being lower is probably that the TCO data represents a more coherent market segment from an energy perspective (the difference between minimum and maximum values are lower for the TCO data despite many more models).

Table 81 LCD-display power consumption from different sources and for different functional units

	Data sources	**IVF summer survey**			**Product case data sets**			**TCO 2005 data 17" LCD**			**TCO 2005 data 15" LCD**		
Operational modes	Functional Unit	*Ave-rage*	Max	Min	*Ave-rage*	Max	Min	*Ave-rage*	Max	Min	*Ave-rage*	Max	Min
Active (Watt)	Per display	*39,9*	70	30	*31,4*	-	-	*25,9*	47	17,1	*16,4*	21,3	12,9
Active (Watt)	Per m^2	*415*	604	330	*345*	-	-	*285*	526	191	*236*	306	185
Active (Watt)	Per Mpixel	*28,5*	39,7	22,9	*23,9*	-	-	*21,5*	59,8	13,7	*20,9*	27,1	16,4
Sleep (Watt)	Per display	*1,2*	2	0,7	*0,9*	-	-	*1,1*	4	0,5	*1,0*	2,1	0,7
Sleep (Watt)	Per m^2	*13,2*	22	7,1	*10,3*	-	-	*12,4*	44,0	5,3	*14*	30,1	9,6
Sleep (Watt)	Per Mpixel	*0,9*	1,5	0,5	*0,7*	-	-	*0,9*	3,1	0,4	*1,2*	2,7	0,9
Off (Watt)	Per display	*1,1*	2	0,7	*0,8*	-	-	*1,0*	3,0	0,5	*0,9*	1,2	0,6
Off (Watt)	Per m^2	*11,7*	22	7,1	*9,2*	-	-	*11,4*	33,6	5,2	*12,2*	17,5	8,6
Off	Per Mpixel	*0,8*	1,5	0,5	*0,6*	-	-	*0,9*	3,8	0,4	*1,1*	1,6	0,8

The figures from the IVF summer survey and the TCO figures indicate that the product case figures 31.4 Watt, 0.9 Watt and 0.8 Watt constitute balanced estimates for the average 2005 17" LCD-display. These are the figures used in the calculations. The figures indicate that the possible error is within plus or minus 20%.

The use phase entries for 17" LCD-displays used in offices are shown in the table below. The energy entries are based on the product case data, see the table above. The time related entries are based on the Task 3.

Table 82 Use phase entries for 17" LCD-displays used in offices.

Description	**Value**	**Unit**	**Yearly [kWh]**
Product Life in years	**6,6**	Years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0314	KWh	81,2004
Idle-mode: No. Of hours, cycles, settings, etc. / year	2586	#	
Sleep-mode: Consumption per hour	0,0009	KWh	3,4182
Sleep-mode: No. Of hours / year	3798	#	
Off-mode: Consumption per hour	0,0008	KWh	1,9
Off-mode: No. Of hours / year	2375	#	
TOTAL over Product Life	**0,57**	**MWh**	
Maintenance, Repairs, Service			
No. of km over Product-Life	0	Km	
Spare parts (fixed, 1% of product materials & manuf.)	68	g	

The use phase entries for LCD-displays used in *homes* are shown in the table below. The energy entries are based on the product case data, see the table above. The time related entries are based on Task 3.

Table 83 Use phase entries for LCD-displays used in homes.

Description	**Value**	**Unit**	**Yearly [kWh]**
Product Life in years	**6,6**	Years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0314	KWh	40,4746
Idle-mode: No. Of hours, cycles, settings, etc. / year	1289	#	
Sleep-mode: Consumption per hour	0,0009	KWh	2,3724
Sleep-mode: No. Of hours / year	2636	#	
Off-mode: Consumption per hour	0,0008	KWh	3,868
Off-mode: No. Of hours / year	4835	#	
TOTAL over Product Life	**0,31**	**MWh**	
Maintenance, Repairs, Service			
No. Of km over Product-Life	0	Km	
Spare parts (fixed, 1% of product materials & manuf.)	68	G	

4.3.5.2 *17" CRT-displays*

In the table below, data from the product case data sets are compared with data derived from the summer survey and data from TCO. Both in the summer survey and for the product case data sets, data representing the best-selling CRT-displays in 2005 were asked for. The number of individual displays is small in all presented data. The TCO data has no correlation to market share.

Table 84 CRT-display power consumption.

Data sources / ***Operational modes***	**IVF summer survey**		**Product case data sets**[7]	**TCO 2005 data 17" CRT**
	Office CRT-display	**Home CRT-display**		
Active, Average (min – max) (Watt)	75		69,5	60,4
Sleep, Average (min – max) (Watt)	9		1,5	2,6
Off, Average (Watt)	1		1,5	2,2

The figures from the IVF summer survey and the TCO figures indicate that the product case figures 69.5 Watt, 1.5 Watt and 1.5 Watt constitute balanced estimates for the average 2005 CRT-display. These are the figures used in the calculations. The figures indicate that the possible error is a bit more than plus or minus 10%.

The use phase entries for CRT-displays used in offices are shown in the table below. The energy entries are based *on an average of all complete datasets* received for CRT-displays, see the table above. The time related entries are based on Task 3.

[7] Average of all complete data sets received for this product case.

Table 85 Use phase entries for CRT displays used in offices.

Description	Value	Unit	Yearly [kWh]
Product Life in years	**6,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0695	kWh	179,727
Idle-mode: No. Of hours, cycles, settings, etc. / year	2586	#	
Sleep-mode: Consumption per hour	0,0015	kWh	5,697
Sleep-mode: No. Of hours / year	3798	#	
Off-mode: Consumption per hour	0,0015	kWh	3,5625
Off-mode: No. Of hours / year	2375	#	
TOTAL over Product Life	**1,25**	**MWh**	65
Maintenance, Repairs, Service			
No. of km over Product-Life	0	km	
Spare parts (fixed, 1% of product materials & manuf.)	164	g	

The use phase entries for CRT-displays used in *homes* are shown in the table below. The energy entries are based *on an average of all complete datasets* received for CRT-displays, see Table 84 above. The time related entries are based on the Task 3.

Table 86 Use phase entries for CRT-displays used in homes.

Description	Value	Unit	Yearly [kWh]
Product Life in years	**6,6**	years	
Electricity			
Idle-mode: Consumption per hour, cycle, setting, etc.	0,0695	kWh	89,5855
Idle-mode: No. Of hours, cycles, settings, etc. / year	1289	#	
Sleep-mode: Consumption per hour	0,0015	kWh	3,954
Sleep-mode: No. Of hours / year	2636	#	
Off-mode: Consumption per hour	0,0015	kWh	7,2525
Off-mode: No. Of hours / year	4835	#	
TOTAL over Product Life	**0,67**	**MWh**	65
Maintenance, Repairs, Service			
No. of km over Product-Life	0	km	
Spare parts (fixed, 1% of product materials & manuf.)	164	g	

4.4 Use phase (system)

Personal computers and monitors operate in many different systems. Below follows a discussion of the more frequent systems. *The conclusion is that a calculation of PCs' effects on systems larger than the PC itself is not relevant in the context of this study.*

To limit the systems analysis the EIPRO study [2006] is used to focus the analysis to the three areas having the greatest environmental impact according to this study. The three areas are:

- food and drink
- private transport
- housing.

Together these areas are responsible for 70 – 80% of the environmental impact of consumption, and account for some 60% of consumption expenditure. In theory, also the environmental impacts from B2B consumption are included indirectly, thus the three product areas should account for about the same percentage of the total environmental impact in society.

Below, the PCs interaction and influence on the three product areas above is described and discussed. It is concluded that environmentally significant PC system aspects in the short term is the influence on room heating, where the PC can be anything from a rather poor heating device to causing a 30% extra energy use because of cooling needs. In the longer term PCs possible influences on travel and transport patterns may well prove significant. However, it is hard to see that any of these system aspects should have an impact on the design of computers other than further accentuating the need to minimize the energy use. It may also be argued that PCs have a large potential for helping us to save energy when used for controlling different systems, for example, the heating system of a building. But that aspect is outside the scope of this study.

4.4.1 Housing

The energy used in a computer is dissipated as heat. Sometimes this heat can be utilized, for example in housing heat exchange systems. Other times the dissipated heat is just causing some extra comfort or discomfort before it is ventilated out and lost. Particularly in offices, the heat is often cooled down, thus causing extra energy losses. So, in a systems perspective including the home or the office where the computer is standing, the electricity used by the computer could during favourable conditions theoretically lead to an equivalent decrease of the energy needed to heat the house or the office. In a systems perspective the energy for the computer could then be regarded as zero. During unfavorable conditions, the waste heat from the computer needs to be cooled down. Modern air-conditioning equipment is quite efficient so only a third of the input energy is needed[8], thus in a systems perspective 1.3 times the computers energy use needs to be put into the system.

To sum up: when the building in which the computer is standing is included in the system, the extra energy for the computer could be anything between 0 to 1.3 times the computers energy requirements. Parameters influencing the size of the multiplication factor are among other:

- Having a heating system is a must for factors below 1. In many European countries, central heating systems are still quite rare.
- Having a heat exchanger for the ventilation air is a must for factors close to zero. Passive heating systems have much less ability to utilize waste heat.

[8] EnergyStar Energy calculator at www.eu-energystar.org

- Having a modern heat pump where you for every kWh in get 4-5 kWh out would also drive the factor close to 1. In such a system, the computer becomes an extremely inefficient heater.
- Having a cooling system is a must for factors above 1. Air-conditioning in private homes is still quite rare in most European countries. In offices, air-conditioning is almost standard today.
- The outdoor temperature decides if you are cooling (factor 1.3) or heating (factor 0-1) or neither (factor 1). The world average global temperature is predicted to increase 2-6 degrees during this century.

There are no studies of the utilization of dissipated heat from electrical appliances in buildings in EU-25. It is hardly relevant to guess at what the average factor for computers would be. Maybe one could conclude from the above that the computer is at best a very poor heating device. At worst the computer causes 30% more energy use than what it consumes itself.

It could be more fruitful to turn the question around. How should are cooling and heating systems be designed to best utilize/cope with the waste heat from PCs and other electrical appliances that we fill our homes and offices with? The benefit of having heat exchanging on the ventilation air is mentioned above. Providing district cooling in combination with district heating is another example of smart utilization of computer waste heat.

4.4.2 Transport

PCs with Internet connection can influence travel habits by making it easier for people to work at home, shop from home, enabling virtual meetings etc. It is true that none of the potential to decrease travelling has yet materialized[9]. However, if PCs are going to lead to increased or decreased travel depends probably more on other factors such as fuel shortage, global warming etc, than the development of PC technology and falls therefore outside the scope of this study.

A more direct influence of PCs on the environmental impacts when travelling is the weight of portable PCs like laptops. To assess this effect we assume that an extra impact will only occur when traveling by road. Rail traffic is more volume than weight dependent and for air travel it is unlikely that the laptop would contribute to any difference in the luggage weight because of so called rebound effects, ie people would carry close to maximum weight regardless if they bring their notebook or not.

One model often used [Earthscan 2004] is to assume that 30% of the fuel consumption of a road vehicle relates to weight. Assuming 0.1 l/km and 2000 kg total weight this would equate to 0.3/2000*0.1=0.015 ml fuel per km and kg. Assuming that a laptop travels 50000 km during its 5.6 years of lifetime, it would mean causing 0.015*50000*2.4 kg=1.8 litres of fuel which is roughly equal to 18

[9] This far it is probably the case that globalisation and the information technology has increased our far away contacts and thus led to an increased travelling.

kWh. This should be compared to the 550 kWh electricity consumed by an office laptop during its lifetime.

4.4.3 Food and drink

It is hard to see any systems where PCs influence what we drink and eat. But PCs could possibly mean a lot to the way we bring home our food and drink as discussed above.

4.5 End-of-life phase

Post Weee conditions means at least 75% recycling of which maximum 10% energy recycling. Data from producers and recycling companies, see Task 3, indicate that the recycling potential of PCs and monitors exceed the 75% goal by far and is in the same order as the default entries in the EcoReport, ie, 95% recycling and 5% landfill. Therefore, for disposal/recycling, the default entries of the EcoReport tool are assumed for all the product cases, see Table 82 below.

The question: PWB easy to disassemble is answered with YES in all product cases. In desktops and laptops, the motherboard, the main printed circuit assembly can be taken out and inserted even by laymen. In monitors the main printed circuit assembly can normally be taken out without tools after opening the encasement according to TCO [2007].

Table 87 Default entries for Disposal & recycling of the EcoReport tool.

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	0	g	1-none
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	0	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	0	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	0	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	0	1%	4
235	Plastics: Materials Recycling (please edit% only)	0	9%	4
236	Plastics: Thermal Recycling (please edit% only)	0	90%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	0	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	0		fixed

4.6 References

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- Communications with Lars Waller at TCO in 2007.
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- Energy Star® Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1)
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- EPIC-ICT. Development of Environmental Performance Indicators for ICT Products on the example of Personal Computers. Draft January 2006. "Data needs and data collection, Generic Modules, Environmental impacts, Impact assessment and weighting, Environmental interpretation and evaluation"
- 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.
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- Request for provision of LCA data. IVF communication to stakeholders 11 November 2006.
- Stakeholder meeting at IVF in Mölndal, Sweden 30 May 2006 .
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- WEEE Directive for Waste of Electric and Electronic Equipment 2002/96/EEC (february 2003)
- Zackrisson et al. Measuring your Company´s Environmental Impact. Earthscan 2004.

5 Definition of base case

The base-cases calculations serve dual purposes: one is to assess the total energy consumption and environmental impact in EU25 from personal computers and monitors in 2005, the other is to give knowledge about design options that could reduce the environmental impact with focus on energy consumption.

The base cases presented are based on the product cases in Task 4. This means four products: desktops, laptops, CRT displays and LCD displays. The usage pattern has a large influence on the results and on the improvement options available. Therefore, the environmental impact from each product is calculated with two usage patterns (representing home and office use) giving in total eight different base-cases.

5.1 Product-specific inputs

The bill of materials for desktops, laptops, CRT displays and LCD displays are presented in Task 4.1.2. The bills of materials include packaging materials.

The methodology developed by VHK (MEEUP 2005) is followed, which means using the EcoReport tool. The 25% steel scrap rate during manufacturing proposed by the EcoReport tool was assumed for all base-case calculations.

The EcoReport tool calculates the impact from distribution as proportional to the volume of packaged product. The volumes in the table below were used for the calculations. The total weight including packaging is also presented in the table. This weight is equal to the sum of the bill of materials.

Table 88 Volumes and weights

Product case	Desktops	Laptops	LCD displays		CRT displays	
			17”	m^2	17”	m^2
Packaged volume (m3)	0,09	0,02	0,04	0,438	0,1	1,11
Weight incl. packaging (kg)	12,8	3,7	6,7	74	16,3	181
Weight excl. packaging (kg)	10,5	2,8	6,0	66	14,1	157

There are no test standards to facilitate calculation of annual resource consumption, thus a EU standard base-case is not relevant. For the real-life situation, the usage pattern and the electricity consumption during the different usage modes are crucial. Please refer to Task 4.3 for the figures used. In addition, 40 km of transport in connection to repairs and maintenance was assumed for the calculations of the use phase impacts for desktops and laptops. No repairs are assumed for monitors, hence no transports for repairs, see Tasks 2.4.3 and 4.3.3. The EcoReport tool further assumes 1% of the bill of materials as spare parts during the use phase. This is a reasonable assumption for laptops and desktops because they are repaired, see 4.3.3 for a discussion on cost of repairs. For the disposal/ recycling phase, the default entries of the EcoReport tool were assumed as most likely for all the product cases. See Task 4.5.

5.2 Base-case environmental impact assessment

The base-case environmental impact assessments are carried out for products sold in 2005. As described in Task 4, the base-cases are chosen to represent an average computer or monitor in 2005.

The EcoReport tool delivers the results in the form of eleven impact categories, which are not comparable with each other. This means that to be really sure about that something is "environmentally" better or not, all eleven[10] impact categories have to point in the same direction. This is rarely the case when trying to compare for example environmental aspects in different life cycle stages.

In task 5.4 it is shown that energy use is of more importance than eutrophication and VOC emissions and that there is a strong correlation between energy use and acidification and greenhouse gases. The indicator GER, Gross Energy Requirement, is therefore in the following always considered as an important indicator which is analysed separately. The other indicators are treated as equally important (since we know no better) and indicative conclusions at component level are drawn based on number of indicators scoring high for a given component, see Appendix 2. This method is suggested by the MEEUP methodology [2005].

Energy related impact categories, like greenhouse gases, acidifying emissions etc are referred to as energy when it is obvious that energy use is the cause, like in the use phase of PCs and monitors. In the figure below it can be seen that the use phase dominates all base cases regarding primary energy. This general finding has been confirmed in other life cycle assessments of computers [EPIC ICT 2005, Atlantic Consulting 1998].

[10] Since Persistent Organic Pollutants and Ozone Depletion emissions are always negligible, there are in reality only nine impact categories to consider.

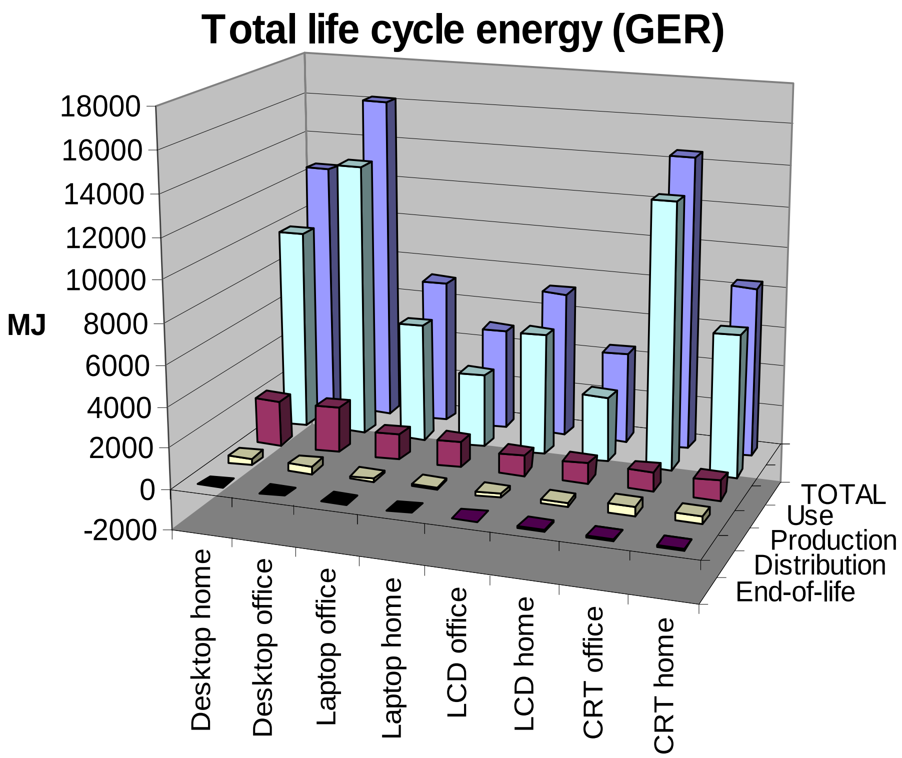

Figure 16 Life cycle primary energy per product

5.2.1 Desktops in offices

The table below show the life cycle environmental impacts of a desktop personal computer used in an office. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 89 Environmental impacts overview for a Desktop PC used in an office.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: Office desktop PC	0	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**627**			564	63	**627**	**0**
2	TecPlastics	g			**501**			451	50	**501**	**0**
3	Ferro	g			**6911**			346	6565	**6911**	**0**
4	Non-ferro	g			**987**			49	937	**987**	**0**
5	Coating	g			**2**			0	2	**2**	**0**
6	Electronics	g			**1439**			767	672	**1439**	**0**
7	Misc.	g			**2287**			114	2172	**2287**	**0**
	Total weight	g			**12753**			2292	10461	**12753**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1917	341	**2259**	**368**	**13571**	158	191	**-33**	**16165**
9	of which, electricity (in primary MJ)	MJ	1090	102	**1192**	**0**	**13464**	0	78	**-78**	**14578**
10	Water (process)	ltr	749	17	**766**	**0**	**904**	0	71	**-71**	**1600**
11	Water (cooling)	ltr	309	90	**399**	**0**	**35877**	0	17	**-17**	**36260**
12	Waste, non-haz./ landfill	g	27328	911	**28239**	**204**	**15880**	782	227	**555**	**44877**
13	Waste, hazardous/ incinerated	g	574	6	**580**	**4**	**316**	1687	88	**1599**	**2499**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	117	21	**138**	**28**	**596**	12	13	**-1**	**761**
15	Ozone Depletion, emissions	mg R-11 ec				negligible					
16	Acidification, emissions	g SO2 eq.	1072	107	**1179**	**94**	**3483**	23	67	**-43**	**4713**
17	Volatile Organic Compounds (VOC)	g	8	4	**12**	**4**	**7**	0	1	**-1**	**22**
18	Persistent Organic Pollutants (POP)	ng i-Teq	183	18	**201**	**1**	**90**	5	1	**5**	**297**
19	Heavy Metals	mg Ni eq.	221	43	**265**	**10**	**254**	43	10	**33**	**563**
	PAHs	mg Ni eq.	139	3	**142**	**7**	**49**	0	8	**-8**	**190**
20	Particulate Matter (PM, dust)	g	81	27	**108**	**101**	**428**	203	3	**200**	**837**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	407	1	**408**	**0**	**91**	13	45	**-32**	**467**
22	Eutrophication	g PO4	7	1	**8**	**0**	**0**	1	1	**0**	**9**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

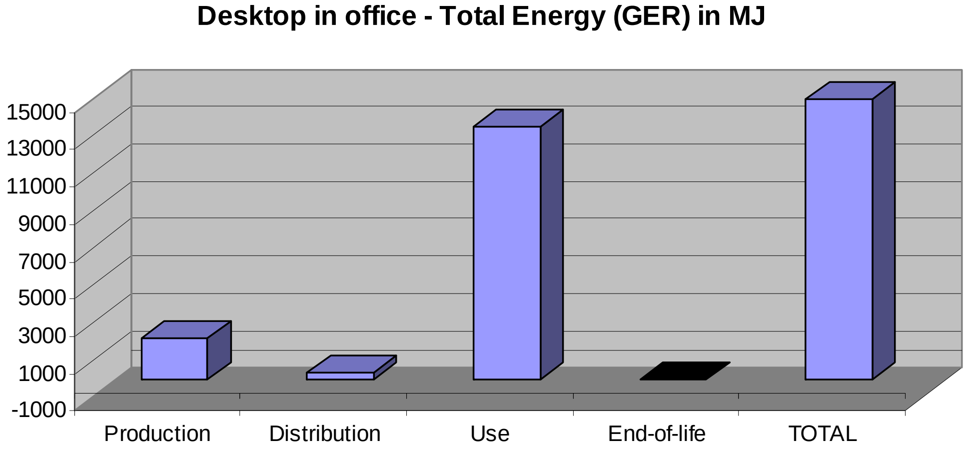

Figure 17   Primary energy for office desktop

Based on the table and figure above and Appendix 2, the following conclusions are drawn:

- In the use phase, about six times more energy is used than in any other phase. Minimizing energy use during the use phase is therefore an obvious improvement area.
- In the production phase: integrated circuits, surface mounted devices, big caps and coils, copper wiring, PWB manufacturing, sheet metal manufacturing and galvanized steel dominate most impact categories, see Appendix 2. This indicates that the motherboard including the processor, the power supply and the steel casing also are relevant improvement areas.

5.2.2 Desktops at home

The table below shows the life cycle environmental impacts of a desktop personal computer used at home. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 90 Environmental impacts overview for a Desktop PC used at home.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: Home desktop PC	0	MZ

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**627**			564	63	**627**	**0**
2	TecPlastics	g			**501**			451	50	**501**	**0**
3	Ferro	g			**6911**			346	6565	**6911**	**0**
4	Non-ferro	g			**987**			49	937	**987**	**0**
5	Coating	g			**2**			0	2	**2**	**0**
6	Electronics	g			**1439**			767	672	**1439**	**0**
7	Misc.	g			**2287**			114	2172	**2287**	**0**
	Total weight	g			**12753**			2292	10461	**12753**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1917	341	**2259**	**368**	**9936**	158	191	**-33**	**12529**
9	of which, electricity (in primary MJ)	MJ	1090	102	**1192**	**0**	**9829**	0	78	**-78**	**10942**
10	Water (process)	ltr	749	17	**766**	**0**	**662**	0	71	**-71**	**1357**
11	Water (cooling)	ltr	309	90	**399**	**0**	**26182**	0	17	**-17**	**26565**
12	Waste, non-haz./ landfill	g	27328	911	**28239**	**204**	**11664**	782	227	**555**	**40662**
13	Waste, hazardous/ incinerated	g	574	6	**580**	**4**	**232**	1687	88	**1599**	**2415**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	117	21	**138**	**28**	**437**	12	13	**-1**	**603**
15	Ozone Depletion, emissions	mg R-11 ec	negligible								
16	Acidification, emissions	g SO2 eq.	1072	107	**1179**	**94**	**2547**	23	67	**-43**	**3777**
17	Volatile Organic Compounds (VOC)	g	8	4	**12**	**4**	**5**	0	1	**-1**	**21**
18	Persistent Organic Pollutants (POP)	ng i-Teq	183	18	**201**	**1**	**66**	5	1	**5**	**273**
19	Heavy Metals	mg Ni eq.	221	43	**265**	**10**	**192**	43	10	**33**	**500**
	PAHs	mg Ni eq.	139	3	**142**	**7**	**42**	0	8	**-8**	**183**
20	Particulate Matter (PM, dust)	g	81	27	**108**	**101**	**408**	203	3	**200**	**817**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	407	1	**408**	**0**	**67**	13	45	**-32**	**444**
22	Eutrophication	g PO4	7	1	**8**	**0**	**0**	1	1	**0**	**9**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

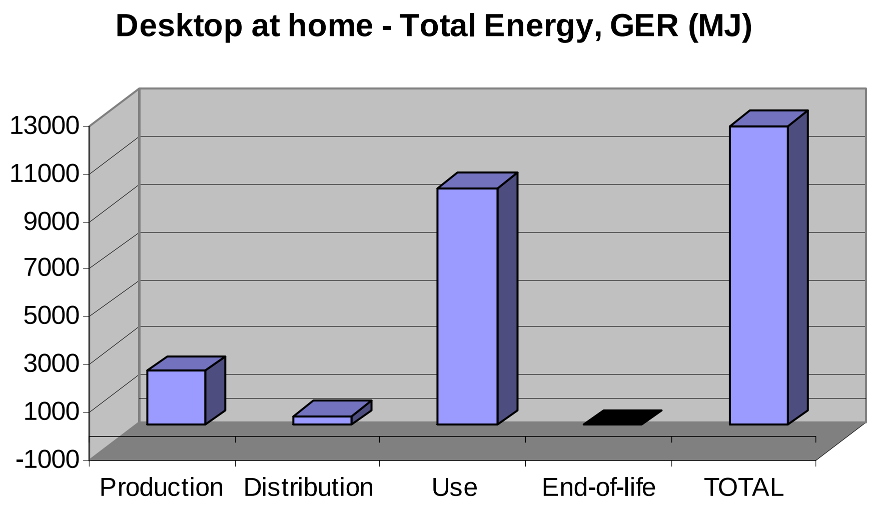

Figure 18 Primary energy for home desktop

The focus areas for improvements are the same as for desktops used in offices, although the use phase energy use is a bit less than in office desktops. The solutions may differ because of the different ways of using computers in homes versus offices.

5.2.3 Laptops

The table below show the life cycle environmental impacts of a laptop personal computer used in an office. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 91 Environmental impacts overview for a laptop used in an office.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: Laptop in office	0	MZ

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**265**			239	27	**265**	**0**
2	TecPlastics	g			**587**			528	59	**587**	**0**
3	Ferro	g			**489**			24	465	**489**	**0**
4	Non-ferro	g			**235**			12	223	**235**	**0**
5	Coating	g			**5**			0	5	**5**	**0**
6	Electronics	g			**914**			514	400	**914**	**0**
7	Misc.	g			**1284**			64	1220	**1284**	**0**
	Total weight	g			**3779**			1381	2398	**3779**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1118	148	**1266**	**122**	**5832**	92	112	**-20**	**7200**
9	of which, electricity (in primary MJ)	MJ	630	30	**660**	**0**	**5730**	0	47	**-47**	**6343**
10	Water (process)	ltr	522	10	**532**	**0**	**387**	0	42	**-42**	**877**
11	Water (cooling)	ltr	249	41	**290**	**0**	**15264**	0	10	**-10**	**15544**
12	Waste, non-haz./ landfill	g	4231	247	**4478**	**85**	**6680**	232	136	**96**	**11340**
13	Waste, hazardous/ incinerated	g	229	3	**232**	**2**	**134**	1167	52	**1114**	**1482**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	71	9	**81**	**10**	**258**	7	8	**-1**	**348**
15	Ozone Depletion, emissions	mg R-11 ec				negligible					
16	Acidification, emissions	g SO2 eq.	445	50	**495**	**30**	**1486**	14	40	**-26**	**1985**
17	Volatile Organic Compounds (VOC)	g	6	2	**8**	**1**	**4**	0	1	**0**	**12**
18	Persistent Organic Pollutants (POP)	ng i-Teq	23	2	**24**	**0**	**38**	2	1	**1**	**64**
19	Heavy Metals	mg Ni eq.	65	4	**69**	**4**	**120**	25	6	**19**	**212**
	PAHs	mg Ni eq.	119	2	**121**	**4**	**33**	0	5	**-5**	**153**
20	Particulate Matter (PM, dust)	g	37	14	**51**	**23**	**385**	118	2	**116**	**574**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	369	0	**369**	**0**	**41**	8	27	**-19**	**391**
22	Eutrophication	g PO4	4	1	**5**	**0**	**0**	0	0	**0**	**5**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

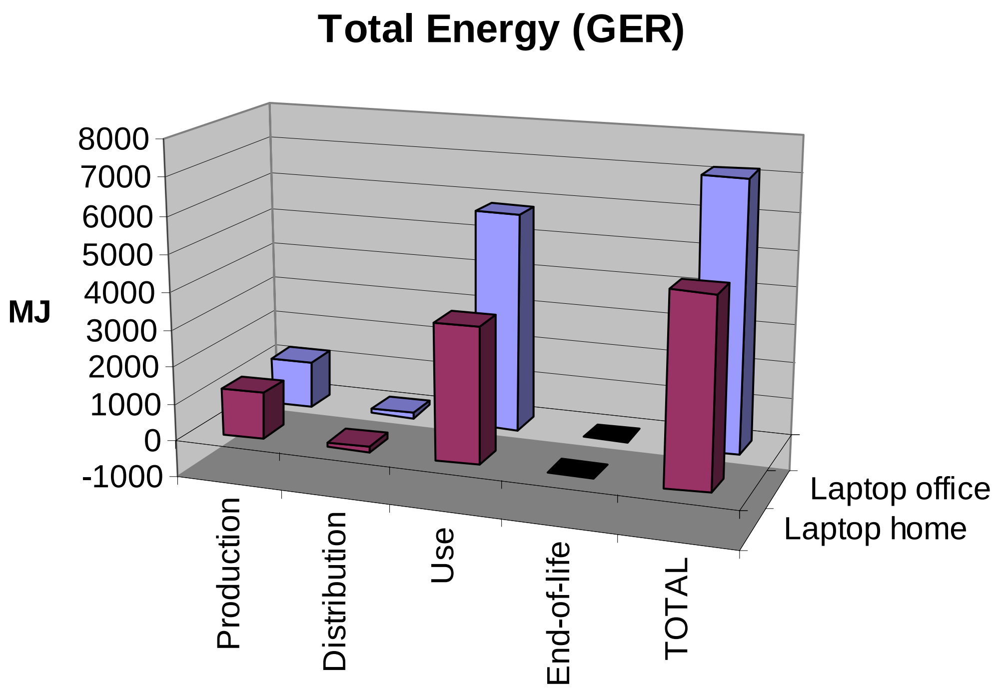

Figure 19 Primary energy for laptops

Based on the table and figure above and Appendix 2, the following conclusions are drawn for **office** laptops:

- In the use phase, about five times more energy is used than in any other phase. Minimizing energy use during the use phase is therefore an obvious improvement area.
- In the production phase: integrated circuits, PWB and PWB manufacturing and big caps and coils dominate many impact categories, see Appendix 2. This indicates that the motherboard including the processor and the battery also are relevant improvement areas. Since the lithium ion battery was approximated to big caps and coils, which was the least bad assumption available, this improvement area needs further validation.
- Care must be exercised so that increasing impacts in the production phase, for example by improving the processor, does not offset improvements in the use phase.

The table below shows the life cycle environmental impacts of a laptop personal computer used at **home**. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 92 Environmental impacts overview for a laptop used at home.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: Laptops at home	0	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**265**			239	27	**265**	**0**
2	TecPlastics	g			**587**			528	59	**587**	**0**
3	Ferro	g			**489**			24	465	**489**	**0**
4	Non-ferro	g			**235**			12	223	**235**	**0**
5	Coating	g			**5**			0	5	**5**	**0**
6	Electronics	g			**914**			514	400	**914**	**0**
7	Misc.	g			**1284**			64	1220	**1284**	**0**
	Total weight	g			**3779**			1381	2398	**3779**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1118	148	**1266**	**122**	**3627**	92	112	**-20**	**4995**
9	of which, electricity (in primary MJ)	MJ	630	30	**660**	**0**	**3525**	0	47	**-47**	**4138**
10	Water (process)	ltr	522	10	**532**	**0**	**240**	0	42	**-42**	**730**
11	Water (cooling)	ltr	249	41	**290**	**0**	**9384**	0	10	**-10**	**9664**
12	Waste, non-haz./ landfill	g	4231	247	**4478**	**85**	**4124**	232	136	**96**	**8783**
13	Waste, hazardous/ incinerated	g	229	3	**232**	**2**	**83**	1167	52	**1114**	**1432**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	71	9	**81**	**10**	**162**	7	8	**-1**	**251**
15	Ozone Depletion, emissions	mg R-11 eq	negligible								
16	Acidification, emissions	g SO2 eq.	445	50	**495**	**30**	**918**	14	40	**-26**	**1418**
17	Volatile Organic Compounds (VOC)	g	6	2	**8**	**1**	**3**	0	1	**0**	**12**
18	Persistent Organic Pollutants (POP)	ng i-Teq	23	2	**24**	**0**	**23**	2	1	**1**	**49**
19	Heavy Metals	mg Ni eq.	65	4	**69**	**4**	**82**	25	6	**19**	**174**
	PAHs	mg Ni eq.	119	2	**121**	**4**	**29**	0	5	**-5**	**148**
20	Particulate Matter (PM, dust)	g	37	14	**51**	**23**	**373**	118	2	**116**	**562**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	369	0	**369**	**0**	**26**	8	27	**-19**	**377**
22	Eutrophication	g PO4	4	1	**5**	**0**	**0**	0	0	**0**	**5**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

The focus areas for improvements are the same as for laptops used in offices. However, the solutions may differ because of the different ways of using computers in homes versus offices. Note that there is less difference between use phase energy and production phase energy (a factor 3) compared to office laptops. Even more care must therefore be exercised so that increasing impacts in the production phase does not offset improvements in the use phase.

5.2.4 LCD-displays – 17”

The table below shows the life cycle environmental impacts of a 17” LCD-display used in an office. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 93 Environmental impacts overview for a 17" LCD-display used in an office.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: LCD display in office	0	MZ

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**1165**			1048	116	**1165**	**0**
2	TecPlastics	g			**1086**			977	109	**1086**	**0**
3	Ferro	g			**3019**			151	2868	**3019**	**0**
4	Non-ferro	g			**229**			11	217	**229**	**0**
5	Coating	g			**1**			0	1	**1**	**0**
6	Electronics	g			**270**			191	79	**270**	**0**
7	Misc.	g			**1038**			52	986	**1038**	**0**
	Total weight	g			**6808**			2431	4377	**6808**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	836	149	**985**	**192**	**6006**	166	118	**48**	**7231**
9	of which, electricity (in primary MJ)	MJ	364	77	**441**	**0**	**6000**	0	10	**-10**	**6431**
10	Water (process)	ltr	151	3	**154**	**0**	**401**	0	9	**-9**	**546**
11	Water (cooling)	ltr	434	41	**475**	**0**	**15993**	0	6	**-6**	**16462**
12	Waste, non-haz./ landfill	g	8165	488	**8653**	**119**	**7038**	418	30	**388**	**16199**
13	Waste, hazardous/ incinerated	g	130	1	**130**	**2**	**139**	2105	11	**2094**	**2366**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	46	9	**55**	**15**	**262**	12	8	**4**	**336**
15	Ozone Depletion, emissions	mg R-11 eq	negligible								
16	Acidification, emissions	g SO2 eq.	235	39	**274**	**48**	**1547**	25	16	**8**	**1878**
17	Volatile Organic Compounds (VOC)	g	2	1	**2**	**2**	**2**	0	0	**0**	**6**
18	Persistent Organic Pollutants (POP)	ng i-Teq	57	5	**63**	**1**	**40**	3	0	**3**	**106**
19	Heavy Metals	mg Ni eq.	38	12	**50**	**6**	**103**	45	1	**44**	**203**
	PAHs	mg Ni eq.	33	0	**33**	**5**	**12**	0	1	**-1**	**49**
20	Particulate Matter (PM, dust)	g	37	7	**44**	**45**	**33**	215	1	**215**	**338**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	112	0	**112**	**0**	**40**	14	5	**9**	**161**
22	Eutrophication	g PO4	4	0	**4**	**0**	**0**	1	0	**1**	**5**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

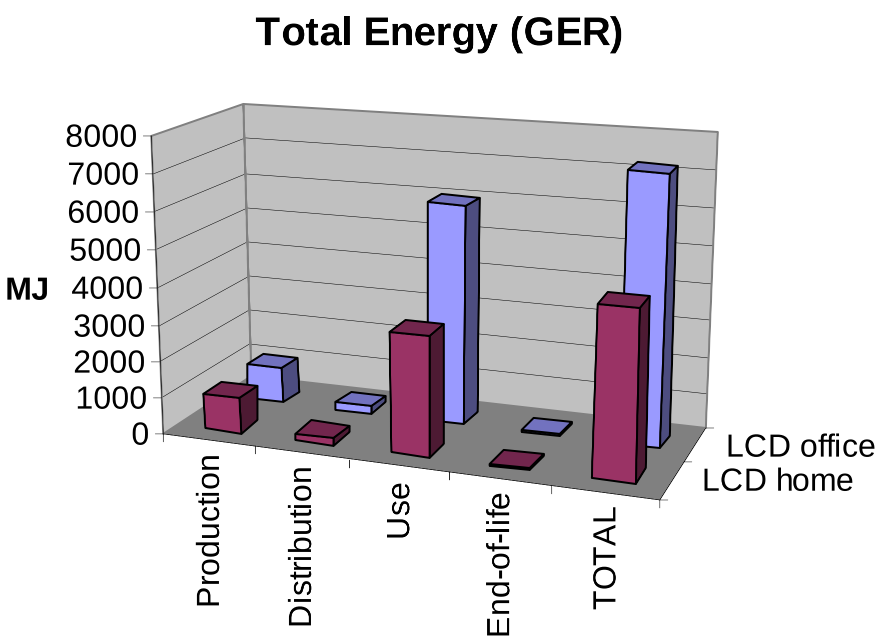

Figure 20   Primary energy for 17" LCD

Based on the figure above and Appendix 2, the following conclusions are drawn for **office** LCD:

- In the use phase, about six times more energy is used than in any other phase. Minimizing energy use during the use phase is therefore an obvious improvement area.
- In the production phase: integrated circuits, plastics and galvanized steel dominate many impact categories, see Appendix 2.

The table below shows the life cycle environmental impacts of a LCD-display used at home. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 94 Environmental impacts overview for a 17"LCD-display used at home.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: LCD display at home	0	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**1165**			1048	116	**1165**	**0**
2	TecPlastics	g			**1086**			977	109	**1086**	**0**
3	Ferro	g			**3019**			151	2868	**3019**	**0**
4	Non-ferro	g			**229**			11	217	**229**	**0**
5	Coating	g			**1**			0	1	**1**	**0**
6	Electronics	g			**270**			191	79	**270**	**0**
7	Misc.	g			**1038**			52	986	**1038**	**0**
	Total weight	g			**6808**			2431	4377	**6808**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	836	149	**985**	**192**	**3247**	166	118	**48**	**4473**
9	of which, electricity (in primary MJ)	MJ	364	77	**441**	**0**	**3242**	0	10	**-10**	**3672**
10	Water (process)	ltr	151	3	**154**	**0**	**217**	0	9	**-9**	**363**
11	Water (cooling)	ltr	434	41	**475**	**0**	**8638**	0	6	**-6**	**9106**
12	Waste, non-haz./ landfill	g	8165	488	**8653**	**119**	**3840**	418	30	**388**	**13000**
13	Waste, hazardous/ incinerated	g	130	1	**130**	**2**	**76**	2105	11	**2094**	**2303**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	46	9	**55**	**15**	**142**	12	8	**4**	**216**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	235	39	**274**	**48**	**836**	25	16	**8**	**1167**
17	Volatile Organic Compounds (VOC)	g	2	1	**2**	**2**	**1**	0	0	**0**	**5**
18	Persistent Organic Pollutants (POP)	ng i-Teq	57	5	**63**	**1**	**22**	3	0	**3**	**88**
19	Heavy Metals	mg Ni eq.	38	12	**50**	**6**	**56**	45	1	**44**	**156**
	PAHs	mg Ni eq.	33	0	**33**	**5**	**7**	0	1	**-1**	**43**
20	Particulate Matter (PM, dust)	g	37	7	**44**	**45**	**18**	215	1	**215**	**322**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	112	0	**112**	**0**	**22**	14	5	**9**	**143**
22	Eutrophication	g PO4	4	0	**4**	**0**	**0**	1	0	**1**	**5**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

The focus areas for improvements are the same as for LCD-display used in offices. However, the solutions may differ because of the different ways of using monitors in homes versus offices.

5.2.5 LCD-displays per m²

The tables below show the life cycle environmental impacts of LCD-displays used in an office and at home per m^2 viewing surface This data is used in the discussions about implementing measures in task 8.

Table 95 Environmental impacts overview for a LCD-display per m^2 used in an office

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: LCD office per m2	39244	MZ

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**12756**			11480	1276	**12756**	**0**
2	TecPlastics	g			**11896**			10706	1190	**11896**	**0**
3	Ferro	g			**33066**			1653	31413	**33066**	**0**
4	Non-ferro	g			**2502**			125	2377	**2502**	**0**
5	Coating	g			**11**			1	11	**11**	**0**
6	Electronics	g			**2960**			2091	869	**2960**	**0**
7	Misc.	g			**11370**			569	10802	**11370**	**0**
	Total weight	g			**74561**			26625	47936	**74561**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	9157	1634	**10791**	**1594**	**65869**	1822	1298	**524**	**78778**
9	of which, electricity (in primary MJ)	MJ	3982	843	**4825**	**1**	**65810**	0	110	**-110**	**70526**
10	Water (process)	ltr	1655	33	**1688**	**0**	**4401**	0	97	**-97**	**5991**
11	Water (cooling)	ltr	4755	445	**5200**	**0**	**175416**	0	70	**-70**	**180546**
12	Waste, non-haz./ landfill	g	89421	5345	**94766**	**794**	**77194**	4578	328	**4250**	**177004**
13	Waste, hazardous/ incinerated	g	1420	8	**1427**	**16**	**1530**	23055	119	**22936**	**25909**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	508	94	**601**	**120**	**2876**	136	89	**47**	**3644**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	2577	426	**3003**	**410**	**16964**	273	180	**92**	**20469**
17	Volatile Organic Compounds (VOC)	g	17	6	**23**	**19**	**25**	5	2	**2**	**70**
18	Persistent Organic Pollutants (POP)	ng i-Teq	629	56	**685**	**4**	**438**	32	1	**31**	**1159**
19	Heavy Metals	mg Ni eq.	414	132	**546**	**40**	**1134**	493	13	**480**	**2200**
	PAHs	mg Ni eq.	356	5	**361**	**25**	**133**	0	11	**-11**	**509**
20	Particulate Matter (PM, dust)	g	406	79	**485**	**490**	**367**	2360	7	**2353**	**3694**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1226	1	**1227**	**1**	**436**	152	58	**94**	**1758**
22	Eutrophication	g PO4	39	2	**41**	**0**	**2**	9	1	**8**	**51**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Table 96 Environmental impacts overview for a LCD-display per m² used at home

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: LCD home per m2	39244	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**12756**			11480	1276	**12756**	**0**
2	TecPlastics	g			**11896**			10706	1190	**11896**	**0**
3	Ferro	g			**33066**			1653	31413	**33066**	**0**
4	Non-ferro	g			**2502**			125	2377	**2502**	**0**
5	Coating	g			**11**			1	11	**11**	**0**
6	Electronics	g			**2960**			2091	869	**2960**	**0**
7	Misc.	g			**11370**			569	10802	**11370**	**0**
	Total weight	g			**74561**			26625	47936	**74561**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	9157	1634	**10791**	**1594**	**35679**	1822	1298	**524**	**48588**
9	of which, electricity (in primary MJ)	MJ	3982	843	**4825**	**1**	**35619**	0	110	**-110**	**40336**
10	Water (process)	ltr	1655	33	**1688**	**0**	**2388**	0	97	**-97**	**3979**
11	Water (cooling)	ltr	4755	445	**5200**	**0**	**94908**	0	70	**-70**	**100038**
12	Waste, non-haz./ landfill	g	89421	5345	**94766**	**794**	**42190**	4578	328	**4250**	**142000**
13	Waste, hazardous/ incinerated	g	1420	8	**1427**	**16**	**834**	23055	119	**22936**	**25213**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	508	94	**601**	**120**	**1558**	136	89	**47**	**2327**
15	Ozone Depletion, emissions	mg R-11 eq				negligible					
16	Acidification, emissions	g SO2 eq.	2577	426	**3003**	**410**	**9190**	273	180	**92**	**12695**
17	Volatile Organic Compounds (VOC)	g	17	6	**23**	**19**	**14**	5	2	**2**	**58**
18	Persistent Organic Pollutants (POP)	ng i-Teq	629	56	**685**	**4**	**240**	32	1	**31**	**961**
19	Heavy Metals	mg Ni eq.	414	132	**546**	**40**	**616**	493	13	**480**	**1682**
	PAHs	mg Ni eq.	356	5	**361**	**25**	**74**	0	11	**-11**	**449**
20	Particulate Matter (PM, dust)	g	406	79	**485**	**490**	**200**	2360	7	**2353**	**3528**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1226	1	**1227**	**1**	**242**	152	58	**94**	**1564**
22	Eutrophication	g PO4	39	2	**41**	**0**	**2**	9	1	**8**	**50**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

5.2.6 CRT-displays – 17”

The table below shows the life cycle environmental impacts of a CRT-display used in an office. In Appendix 2, the environmental impacts for the production phase are shown in detail.

Table 97 Environmental impacts overview for a 17” CRT-display used in an office.

Nr	Life cycle Impact per product:		Date	Author
0	EuP Lot 3 prep study: CRT in office		0	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**1964**			1767	196	**1964**	**0**
2	TecPlastics	g			**448**			403	45	**448**	**0**
3	Ferro	g			**126**			6	120	**126**	**0**
4	Non-ferro	g			**236**			12	224	**236**	**0**
5	Coating	g			**6**			0	6	**6**	**0**
6	Electronics	g			**341**			222	119	**341**	**0**
7	Misc.	g			**13276**			664	12612	**13276**	**0**
	Total weight	g			**16397**			3075	13322	**16397**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	824	132	**956**	**404**	**13106**	212	162	**50**	**14515**
9	of which, electricity (in primary MJ)	MJ	377	62	**439**	**0**	**13101**	0	15	**-15**	**13525**
10	Water (process)	ltr	224	4	**227**	**0**	**875**	0	13	**-13**	**1090**
11	Water (cooling)	ltr	445	37	**482**	**0**	**34930**	0	8	**-8**	**35404**
12	Waste, non-haz./ landfill	g	5843	347	**6190**	**221**	**15247**	1006	43	**962**	**22620**
13	Waste, hazardous/ incinerated	g	258	1	**259**	**4**	**304**	2289	16	**2273**	**2841**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	42	8	**50**	**31**	**572**	16	11	**5**	**657**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	342	36	**378**	**103**	**3376**	32	23	**8**	**3865**
17	Volatile Organic Compounds (VOC)	g	74	1	**75**	**4**	**6**	1	0	**0**	**85**
18	Persistent Organic Pollutants (POP)	ng i-Teq	7	0	**8**	**1**	**86**	7	0	**7**	**102**
19	Heavy Metals	mg Ni eq.	119	1	**120**	**11**	**226**	58	2	**56**	**414**
	PAHs	mg Ni eq.	25	1	**25**	**8**	**26**	0	1	**-1**	**58**
20	Particulate Matter (PM, dust)	g	270	7	**277**	**112**	**75**	274	1	**273**	**737**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	121	0	**121**	**0**	**86**	18	8	**10**	**217**
22	Eutrophication	g PO4	5	0	**5**	**0**	**0**	1	0	**1**	**6**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

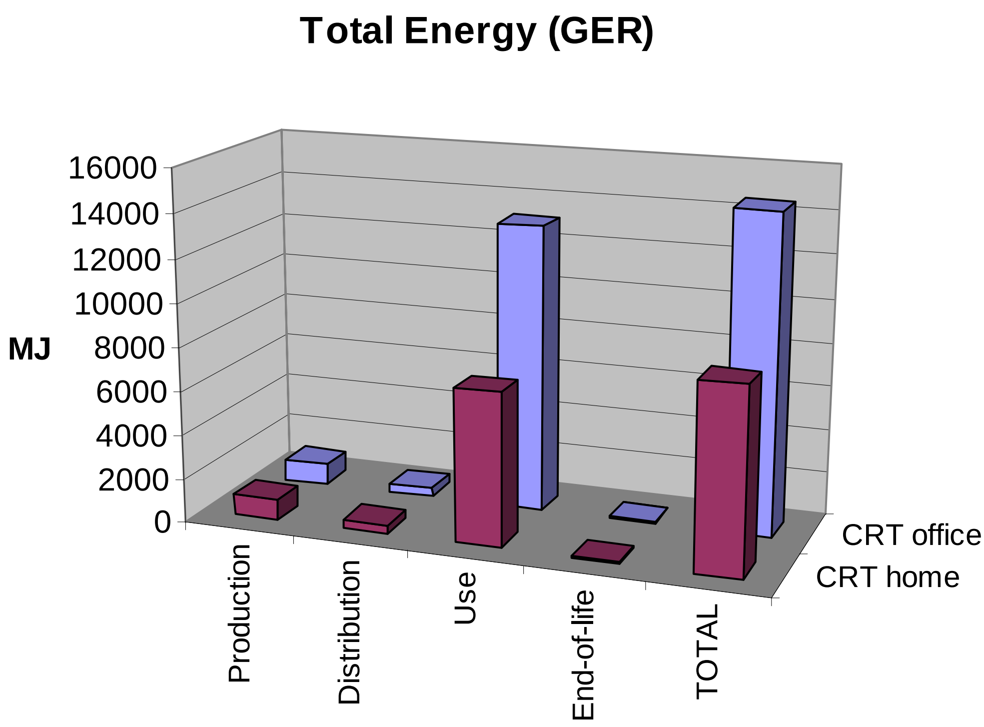

Figure 21   Primary energy for 17" CRT

Based on the figure and table above and Appendix 2, the following conclusions are drawn for **office** CRTs:

- In the use phase, about thirteen times more energy is used than in any other phase. Minimizing energy use during the use phase is therefore an obvious improvement area, if this product is going to remain in the market
- In the production phase: the CRT screen, plastics and integrated circuits dominate many impact categories, see Appendix 2. This indicates that the CRT screen, printed circuit assemblies and the casing are focus areas for improvements

The table below shows the life cycle environmental impacts of a 17" CRT-display used at home.

Table 98 Environmental impacts overview for a 17" CRT-display used at home.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: CRT at home	0	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**1964**			1767	196	**1964**	**0**
2	TecPlastics	g			**448**			403	45	**448**	**0**
3	Ferro	g			**126**			6	120	**126**	**0**
4	Non-ferro	g			**236**			12	224	**236**	**0**
5	Coating	g			**6**			0	6	**6**	**0**
6	Electronics	g			**341**			222	119	**341**	**0**
7	Misc.	g			**13276**			664	12612	**13276**	**0**
	Total weight	g			**16397**			3075	13322	**16397**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	824	132	**956**	**404**	**6994**	212	162	**50**	**8403**
9	of which, electricity (in primary MJ)	MJ	377	62	**439**	**0**	**6989**	0	15	**-15**	**7413**
10	Water (process)	ltr	224	4	**227**	**0**	**468**	0	13	**-13**	**682**
11	Water (cooling)	ltr	445	37	**482**	**0**	**18631**	0	8	**-8**	**19105**
12	Waste, non-haz./ landfill	g	5843	347	**6190**	**221**	**8160**	1006	43	**962**	**15534**
13	Waste, hazardous/ incinerated	g	258	1	**259**	**4**	**164**	2289	16	**2273**	**2700**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	42	8	**50**	**31**	**305**	16	11	**5**	**390**
15	Ozone Depletion, emissions	mg R-11 eq	negligible								
16	Acidification, emissions	g SO2 eq.	342	36	**378**	**103**	**1802**	32	23	**8**	**2291**
17	Volatile Organic Compounds (VOC)	g	74	1	**75**	**4**	**3**	1	0	**0**	**83**
18	Persistent Organic Pollutants (POP)	ng i-Teq	7	0	**8**	**1**	**46**	7	0	**7**	**62**
19	Heavy Metals	mg Ni eq.	119	1	**120**	**11**	**121**	58	2	**56**	**309**
	PAHs	mg Ni eq.	25	1	**25**	**8**	**14**	0	1	**-1**	**46**
20	Particulate Matter (PM, dust)	g	270	7	**277**	**112**	**41**	274	1	**273**	**704**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	121	0	**121**	**0**	**46**	18	8	**10**	**177**
22	Eutrophication	g PO4	5	0	**5**	**0**	**0**	1	0	**1**	**6**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

The focus areas for improvements are the same as for CRT-display used in offices. However, the solutions may differ because of the different ways of using monitors in homes versus offices.

5.2.7 CRT-displays per m²

The tables below show the life cycle environmental impacts of CRT-displays used in an office and at home per m^2 viewing surface. This data is used in the discussions about implementing measures in task 8.

Table 99 Environmental impacts overview for a CRT-display per m^2 used in an office.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: CRT per m2	11 June 2007	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**21769**			19592	2177	**21769**	**0**
2	TecPlastics	g			**4967**			4470	497	**4967**	**0**
3	Ferro	g			**1397**			70	1327	**1397**	**0**
4	Non-ferro	g			**2619**			131	2488	**2619**	**0**
5	Coating	g			**67**			3	64	**67**	**0**
6	Electronics	g			**3783**			2466	1317	**3783**	**0**
7	Misc.	g			**147184**			7359	139825	**147184**	**0**
	Total weight	g			**181785**			34092	147693	**181785**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	9135	1459	**10594**	**3960**	**145303**	2346	1793	**553**	**160409**
9	of which, electricity (in primary MJ)	MJ	4180	682	**4862**	**3**	**145246**	0	163	**-163**	**149948**
10	Water (process)	ltr	2480	41	**2521**	**0**	**9705**	0	145	**-145**	**12082**
11	Water (cooling)	ltr	4928	411	**5339**	**0**	**387245**	0	84	**-84**	**392500**
12	Waste, non-haz./ landfill	g	64779	3847	**68625**	**1933**	**169034**	11152	482	**10670**	**250262**
13	Waste, hazardous/ incinerated	g	2862	11	**2873**	**38**	**3374**	25379	178	**25201**	**31487**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	465	85	**550**	**298**	**6342**	175	125	**50**	**7240**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	3790	397	**4188**	**1020**	**37430**	350	259	**91**	**42729**
17	Volatile Organic Compounds (VOC)	g	819	8	**827**	**49**	**63**	6	4	**3**	**942**
18	Persistent Organic Pollutants (POP)	ng i-Teq	79	4	**84**	**11**	**953**	77	2	**76**	**1123**
19	Heavy Metals	mg Ni eq.	1323	12	**1335**	**98**	**2504**	642	19	**623**	**4561**
	PAHs	mg Ni eq.	273	7	**280**	**60**	**289**	0	16	**-16**	**612**
20	Particulate Matter (PM, dust)	g	2991	81	**3072**	**1242**	**829**	3040	9	**3030**	**8174**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1341	1	**1342**	**3**	**950**	196	88	**108**	**2402**
22	Eutrophication	g PO4	54	3	**57**	**0**	**5**	11	1	**10**	**72**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Table 100 Environmental impacts overview for a 17“ CRT-display used at home.

Nr	Life cycle Impact per product:		Date	Author
0	EuP Lot 3 prep study: CRT home per m2		11 May 2007	MZ

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**21769**			19592	2177	**21769**	**0**
2	TecPlastics	g			**4967**			4470	497	**4967**	**0**
3	Ferro	g			**1397**			70	1327	**1397**	**0**
4	Non-ferro	g			**2619**			131	2488	**2619**	**0**
5	Coating	g			**67**			3	64	**67**	**0**
6	Electronics	g			**3783**			2466	1317	**3783**	**0**
7	Misc.	g			**147184**			7359	139825	**147184**	**0**
	Total weight	g			**181785**			34092	147693	**181785**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	9135	1459	**10594**	**3960**	**77544**	2346	1793	**553**	**92650**
9	of which, electricity (in primary MJ)	MJ	4180	682	**4862**	**3**	**77486**	0	163	**-163**	**82189**
10	Water (process)	ltr	2480	41	**2521**	**0**	**5188**	0	145	**-145**	**7565**
11	Water (cooling)	ltr	4928	411	**5339**	**0**	**206554**	0	84	**-84**	**211809**
12	Waste, non-haz./ landfill	g	64779	3847	**68625**	**1933**	**90471**	11152	482	**10670**	**171699**
13	Waste, hazardous/ incinerated	g	2862	11	**2873**	**38**	**1813**	25379	178	**25201**	**29925**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	465	85	**550**	**298**	**3385**	175	125	**50**	**4283**
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	3790	397	**4188**	**1020**	**19982**	350	259	**91**	**25281**
17	Volatile Organic Compounds (VOC)	g	819	8	**827**	**49**	**37**	6	4	**3**	**916**
18	Persistent Organic Pollutants (POP)	ng i-Teq	79	4	**84**	**11**	**508**	77	2	**76**	**679**
19	Heavy Metals	mg Ni eq.	1323	12	**1335**	**98**	**1342**	642	19	**623**	**3398**
	PAHs	mg Ni eq.	273	7	**280**	**60**	**155**	0	16	**-16**	**478**
20	Particulate Matter (PM, dust)	g	2991	81	**3072**	**1242**	**457**	3040	9	**3030**	**7801**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1341	1	**1342**	**3**	**513**	196	88	**108**	**1965**
22	Eutrophication	g PO4	54	3	**57**	**0**	**3**	11	1	**10**	**70**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

5.3 Base-case life cycle costs

The input figures in the table below were used for the calculations of life cycle costs and EU totals.

Table 101 Input figures for LCC and EU totals.

Description / Base-case	Desktop office	Desktop home	Laptop office	Laptop home	LCD office	LCD home	CRT office	CRT home	Total
Product life (years)	6,6	6,6	5,6	5,6	6,6	6,6	6,6	6,6	
Annual sales (mln. units/year)	8,4	19,6	12	8	7,8	18,2	1,2	2,8	78
EU Stock 2005 (mln. Units)	44,0	102	36,5	24	20,5	47,5	24	57	355,5
Product price (Euro/unit)	620	520	1242	990	201	201	73	73	
Electricity rate (Euro/kWh)	0,136	0,136	0,136	0,136	0,136	0,136	0,136	0,136	
Repair & mainten. (Euro/unit)	125	125	125	125	0	0	0	0	
Discount rate (%)	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	
Present Worth Factor (years)	6,17	6,17	5,28	5,28	6,17	6,17	6,17	6,17	
Overall Improvem. Ratio	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	

The product life and repair & maintenance costs are from Task 4.3.2

Annual sales, EU stock, the electricity price and the discount rate are from Task 2. The EcoReport calculates the Present worth factor automatically from the discount rate and the product life [MEEUP 2205]. Product price is the average price of the computers and monitors from the summer survey, see Task 2. Value added tax is not added because discounts in the same order of magnitude are very frequent.

The overall improvement ratio is left at the default value 1,0. This means that in the model, there was no significant change in the energy consumption of PCs and monitors between 2002 and 2005. There are data and arguments supporting both decreasing and increasing energy consumption per unit during this period.

The Life cycle costs per product are presented in the table below. In Table 104, the life cycle cost per product is aggregated to EU-25 level using sales in 2005.

Table 102 Life cycle costs per product.

Description / Base-case	Desktop office	Desktop home	Laptop office	Laptop home	LCD office	LCD home	CRT office	CRT home
Product price (Euro)	620	520	1242	990	201	201	73	73
Electricity (Euro)	163	119	70	43	73	39	159	85
Repair & maintenance (Euro)	117	117	117	117	0	0	0	0
Life cycle cost 2005 (Euro)	900	756	1430	1151	274	240	232	158

For desktops and laptops the total life cycle cost is dominated by product price. However, for all product categories, the life cycle electricity cost is between 40-160 Euro. The life cycle cost of electricity is an indicator how much the consumer would be willing to spend on energy-saving features.

Table 103 Total annual expenditure for all products sold in 2005 in EU-25.

Description / Base-case	Desktop office	Desktop home	Laptop office	Laptop home	LCD office	LCD home	CRT office	CRT home	Total
Product (mln Euro)	5208	10192	14904	7920	1568	3658	88	204	43742
Electricity (mln Euro)	1162	1965	483	195	241	302	617	781	5746
Repair & maintenance (mln Euro)	833	1932	815	536	0	0	0	0	4116
Total annual LCC in EU-25 (mln Euro)	7203	14089	16202	8651	1809	3960	704	986	53604

5.4 EU Totals

EU totals are calculated in two ways: One is based on the computers manufactured and sold in 2005. The total environmental impact in EU-25 in 2005 from the computers sold that year is multiplied by the expected product life, see table below. The other way of calculating is based on the installed stock of PCs and monitors in 2005.

*Table 104 EU-25 totals of PCs **sold 2005**, life cycle environmental impacts.*

Description / Base-case	Desktop office	Desktop home	Laptop office	Laptop home	LCD office	LCD home	CRT office	CRT home	Total
Sales 2005 (mln. units/year)	8,4	19,6	12	8	7,8	18,2	1,2	2,8	78
Product life (years)	6,6	6,6	5,6	5,6	6,6	6,6	6,6	6,6	
Total Energy, GER (PJ)	136	246	86	40	56	81	17	24	686
Greenhouse Gases (Mt CO2eq)	6	12	4	2	3	4	1	1	33
Acidifying agents (kt SO2eq)	40	74	24	11	15	21	5	6	196
Volatile Org. Compounds (kt)	0,2	0,4	0,1	0,1	0,1	0,1	0,1	0,2	1
Persistent Org. Pollutants (g i-Teq)	2	5	1	0,4	1	2	0,1	0,2	12
Heavy Metals (ton Ni eq)	5	10	3	1	2	3	0,5	1	24
PAHs (ton Ni eq)	2	4	2	1	0,4	1	0,1	0,1	10
Particulate Matter (kt)	7	16	7	4	3	6	1	2	46
Heavy Metals to water (ton Hg/20)	4	9	5	3	1	3	0,3	0,5	25
Eutrophication (kt PO4)	0,1	0,2	0,1	0,04	0,04	0,1	0,008	0,02	0,5

In the figure below, the table above is shown in graphical form.

Note that since all base cases are calculated separately, the EU total calculations account for that extra monitors often are used in offices. From Table 44 it can be deduced that there are approximately 2-3 million more monitors than desktops.

In the figure below, the base cases are ordered in decreasing Gross Energy Requirement (GER) at EU-25 level, considering sales in 2005. Desktops used in homes dominate GER, due to the large sales volumes.

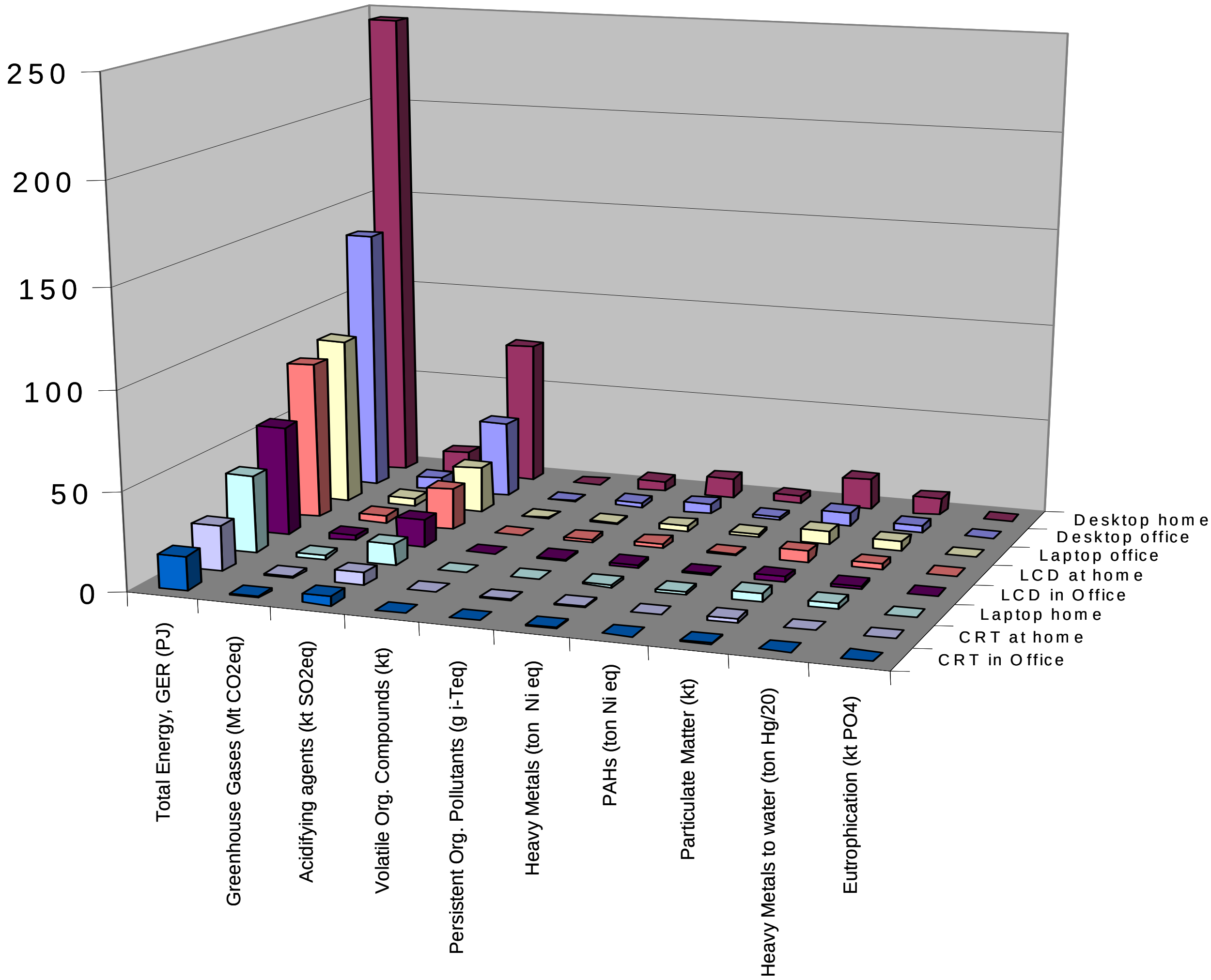

Figure 22 EU-25 totals of PCs and Monitors sold in 2005

In the figure below the EU-25 totals of PCs and Monitors sold in 2005 are shown normalized against Western European total yearly emissions according to Huijbregts [2003]. It can be seen that greenhouse gases and acidifying agents are more important than volatile organic compounds and eutrophying substances. The latter are approximately 100 times less important than the former. For the other impact categories there are unfortunately no normalization figures available, hence it is not possible to draw any conclusions regarding their relative importance.

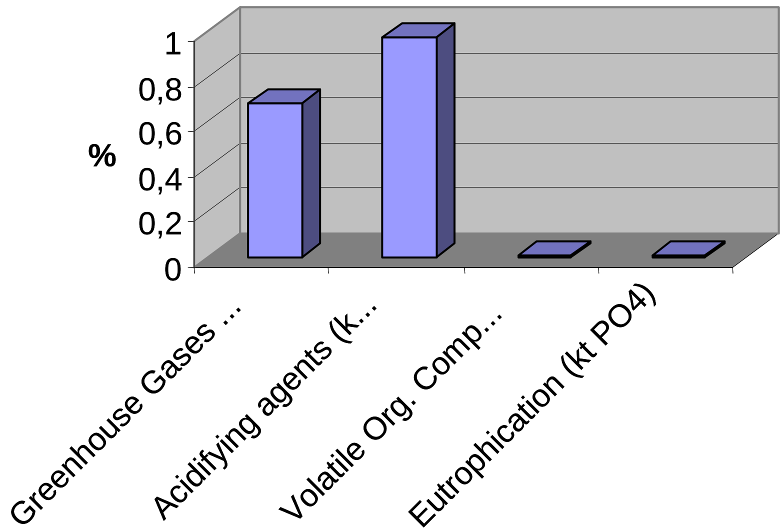

Figure 23 EU-25 totals of PCs and Monitors sold in 2005 normalized against Western Europe total yearly emissions [Huijbregts, 2003].

In the figure below is shown the contribution from the Use phase to the total value for respective impact category, for LCD-displays. The use phase inputs are electricity (88% of total electricity) and a small amount of spare parts (1% of materials). It can be seen that the Use phase contributes a lot to GER, Greenhouse gases and Acidifying agents, between 66-73%. The explanation is that European electricity involves a lot of coal burning. The other base cases show similar patterns. Therefore, in the following tasks, Total Energy, GER, is used as the main indicator for environmental impact.

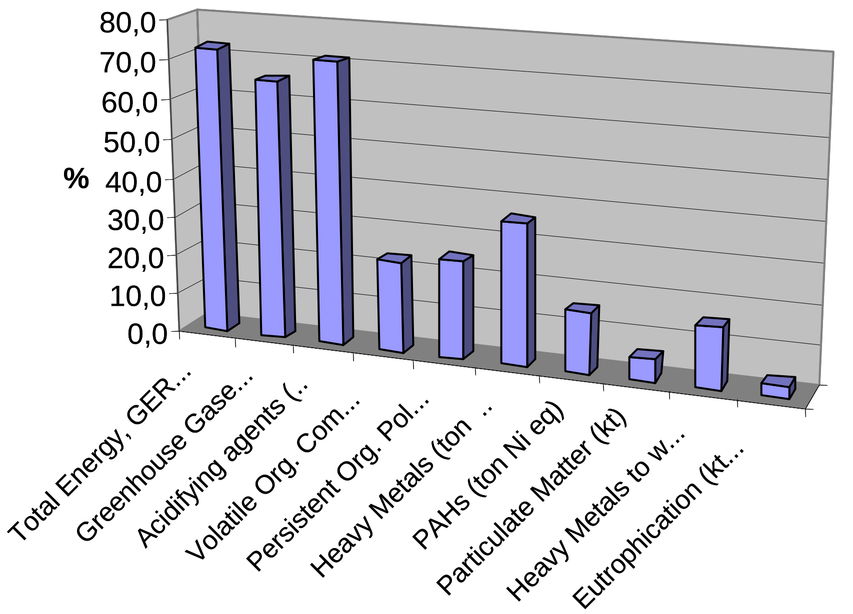

Figure 24 Contribution from the use phase electricity (for LCD-displays in homes sold 2005) to respective impact categories

For comparison, the figure below shows life cycle impacts in GER for the base cases per product. At the product level desktops in offices dominate environmental impacts due to more intensive usage.

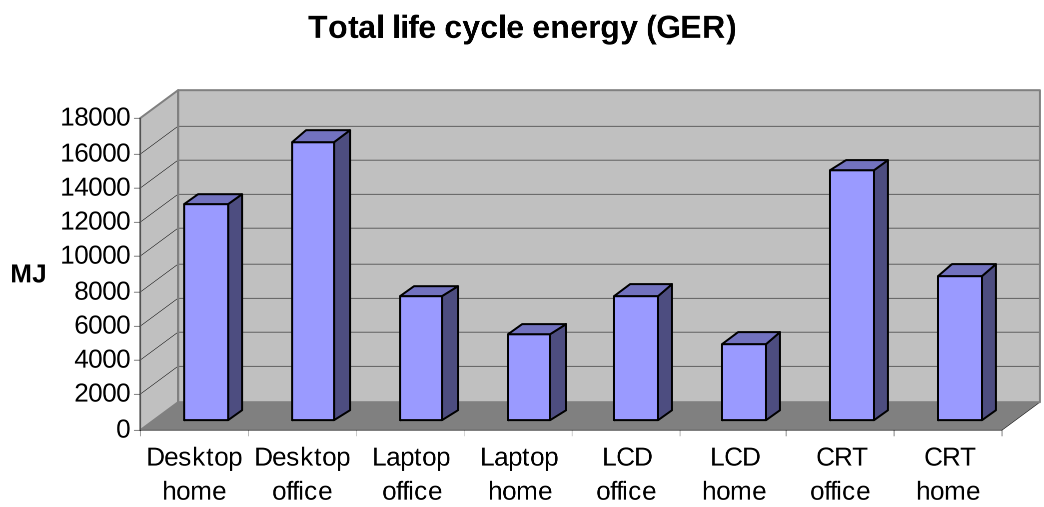

Figure 25 Life cycle impacts per product.

Table 105 EU-25 total environmental impacts of ***stock*** *of PCs in 2005.*

Description / Base-case	**Desktop office**	**Desktop home**	**Laptop office**	**Laptop home**	**LCD office**	**LCD home**	**CRT office**	**CRT home**	**Total**
EU Stock 2005 (mln. Units)	44,0	102	36,5	24	20,5	47,5	24	57	355,5
Total Energy, GER (PJ)	112	204	54	26	28	46	49	64	585
Greenhouse Gases (Mt CO2eq)	5	10	3	1	1	2	2	3	28
Acidifying agents (kt SO2eq)	34	63	16	8	7	12	13	17	170
Volatile Org. Compounds (kt)	0	0	0	0	0	0	0	0	1
Persistent Org. Pollutants (g i-Teq)	2	5	1	0	1	1	0	0	11
Heavy Metals (ton Ni eq)	4	9	2	1	1	2	1	2	22
PAHs (ton Ni eq)	2	3	2	1	0	1	0	0	9
Particulate Matter (kt)	6	14	5	3	2	6	1	2	40
Heavy Metals to water (ton Hg/20)	4	8	4	3	1	2	0	1	24
Eutrophication (kt PO4)	0	0	0	0	0	0	0	0	0
Annual electricity use per product (kWh)	194	141	98	61	86	47	189	102	

A reason that environmental impacts are higher for PCs and monitors sold in 2005 compared to impacts from the stock 2005, is that annual sales 2005 multiplied by product life implies more units (about 495 million) than the stock in 2005 (350 million). More PCs and monitors means more environmental impact everything else being equal. But future technologies have already been implemented in 2006 and 2007 years models, so everything else is not going to be equal. This will be discussed in Tasks 6 and 7.

Figures 22 and 25 indicate that the following priorities of improvements would be relevant:

- In a EU-perspective, desktops used in homes should be prioritized for improvements since they contribute to most environmental impacts due to larger volumes, see Figure 22.
- At the product level, desktops in offices and CRTs in offices contribute to most environmental impacts. This could be an incentive to organisations to implement energy efficiency programs
- In an energy perspective, laptops are preferable to desktops and LCD-screens are preferable to CRT-screens.

5.5 EU-25 Total system impact

As discussed in Task 4, a PC, can be part of many different systems but mostly operates within its own system. Thus, no calculations are made of the PC as part of a larger system than in 5.4.

The EIPRO study [2006], does not contain figures enabling a comparison of environmental impact from PCs. A study of electricity consumption in the Enlarged European Union 2007, indicate that the residential sector in EU-25 used 765 TWh in year 2004. Multiplying the stock figures for the home products in the table above with respective product's yearly electricity use and summing up, yields 24 TWh, ie 3% of the electricity used in the residential sector.

5.6 References

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- Huijbregts, M. A. J. , L. Breedveld, G. Huppes, A. de Koning, L. van Oers and S. Suh. Normalisation figures for environmental life-cycle assessment: The Netherlands (1997/1998), Western Europe (1995) and the world (1990 and 1995). Journal of Cleaner Production, Volume 11, Issue 7, November 2003, Pages 737-748
- Bertoldi P, Atanasiu B. Electricity Consumption and Efficiency Trends in the Enlarged European Union. Status report 2006. Institute for environment and Sustainability. 2007. EUR 22753 EN.
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- Atlantic Consulting and IPU. LCA Study (Version 1.2), EU Ecolables for Personal Computers, March 1998.

6 Technical Analysis BAT

6.1 Task and Procedure

The main task of this part of the report is to describe best available technologies, BAT, for Personal Computers and Computer Monitors. By BAT, we here mean technologies, which are best from the environmental and energy efficiency point of view based on the findings in task 5:

For desktops (both for office and home) the focus areas found in task 5 are:

- Energy use during the use phase
- During the production phase the motherboard including the processor, the power supply and the steel casing dominate most impact categories.

For laptops (both for office and home) the focus areas found in task 5 are

- Energy use during use phase
- During the production phase the motherboard including the processor and the battery dominate most impact categories.

For LCD-displays (both for office and home) the focus areas found in task 5 are

- Energy use during use phase
- During the production phase integrated circuits, plastics and galvanized steel dominate most impact categories.

For CRT-displays (both for office and home) the focus areas found in task 5 are

- Energy use during use phase
- During the production phase integrated circuit, the CRT-screen and plastics dominate the impact categories.

There are several options for improving the PC of today both from the energy consumption point of view and from the view of other environmental impacts of the PCs and computer monitors. The producers have already introduced many improvements in the products, while others are in the pipeline. We can foresee a range of improvements in the near future. The improvements range from hardware changes to simplifications in the systems to promote users to accept and adopt the different power management options already available today.
The PCs of tomorrow will in some cases move from the previous concept of being just a computer to become a multimedia station for different everyday tasks and the PCs will be a part of the furniture in the living room.

This change in user pattern will either require other selling arguments for the PC or other implementing measures. There will be a need for education in the marketing organizations and an information campaign aimed towards the consumers.

The clock frequency of the processor in the PC is one example. From a user perspective the clock frequency of the processor is of limited value when the performance of a PC is measured. There are several other issues that need to be addressed in order to make an intelligent choice. Among these the type of

processor, single or multi core, the bus frequency, the size of the internal memory (RAM) and the size of the hard drive are of importance. Also the power consumption when the PC is on and off can be of importance for customers. In addition the selection of operating system is complex since it influence both the possible hardware and software that can be used on the PC.
From an energy consumption point of view the trend has been that every new generation of PCs have consumed more energy than the previous generation. This trend has, however, been broken in 2006 with the introduction of multi core processors and other improvements.
When adequate in the presentation the difference between Desktop and Laptop PCs are indicated. The Integrated computer can incorporate the same benefits and drawbacks as other PCs but the market penetration of this type of PC is less than 2% so no special considerations are made for this product.

The complexity of a modern PC is similar to that of a car. The best PC for one user is different from the best PC for another user just like the most appropriate car for one family is different from the most appropriate car for another family. It all depends on the purpose of the PC or car. Another similarity is the feeling users have that they don't understand what's going on inside the cabinet or under the hood. There is a need for user/consumer education regarding both the use of the PCs and the process of purchasing a PC.

The procedure to gather information to this report is based on IVF survey [IVF survey 2006] among stakeholders followed by in-depth interviews in order to clarify some information. In-depth interviews have been carried out with many manufacturers representing computer, monitor and component industry. In addition literature studies combined with our own experience has been used. In particular a study performed in the United States sponsored by the US Government with the title "Energy Consumption by Office and Telecommunication Equipment in Commercial Buildings, Volume II: Energy Savings Potential", [TIAX] has been used.

This report entails a technical analysis not only of current products on the market but on currently available technology, expected to be introduced at product level within 2-3 years. It provides part of the input for the identification of part of the improvement potential (task 7), i.e. the part that relates especially to the best available technology.

6.2 State-of-the-art in applied research for the product (prototype level)

6.2.1 Best available products

In order to give an idea about the possible improvements, products considered as "Best available" on the market (home and office combined) are described. To be noted is that the products are "best" regarding energy consumption, with focus on active/idle mode, and that the other performances has not been discussed although the products are in the range of products described in this study. Computers are taken as the best of Energy star list of Computers "Final computer dataset 10-20-06". It is a list of computers gathered by Energy Star in order to decide limits for Energy Star. Industry has provided Energy Star with product information for the list, following the test methods of Energy Star 4. LCD and CRT computer monitors are taken as the best of all monitors labeled at TCO 2005. For reasons of confidentiality, the brand and model names are not included.

Computers

Desktop computer

A desktop computer, included in the Energy Star list, equipped with dual core processor and processor speed of 1,67 GHz, total system memory of 512 MB, hard drive storage of 80 GB and a power supply with ≥85% average efficiency, has the following energy consumption:

- Off/standby mode: 1.10W
- Sleep mode: 2.6 W
- Idle mode: 23 W

Laptop computer

A laptop computer, included in the Energy Star list, equipped with total system memory of 1024 MB, hard drive storage of 80 GB and a power supply with ≥84% average efficiency has the following energy consumption:

- Off/standby mode: 0.38W
- Sleep mode: 0.82 W
- Idle mode: 6.8 W

Note that the screen is shut off during the energy measurements.

Monitors

LCD Monitor per product

A LCD Monitor, labeled by TCO in 2005, with size 17", format 4x3 and resolution 1024x768 has the following energy consumption:

- Off/standby mode: 0.67W
- Sleep mode: 0.67 W
- On mode: 17.1 W

CRT Monitor

A CRT Monitor, labeled by TCO in 2005, with size 17", format 4x3 and resolution 1024x768 has the following energy consumption:

- Off/standby mode: 3.8W
- Sleep mode: 3.8 W
- On mode: 51.7 W

Power per area for Monitors

In the statistics available at TCO, the best available technology for active power per area for a CRT is 281 W/m^2 and for an LCD is 184 W/m^2.

LED Monitors and Laptops

Up to the summer of 2006 the backlights available for computer monitor size displays have been typically mercury-filled fluorescent lamps. Since then a few big manufacturers have realised some full size monitories with LED (light emission diode) backlights that are commercially available. NEC's and Samsung's monitories can be bought now, and Acer and LG will also start selling in the near future. There is also a Sony notebook computer series sold with LED backlight units in the monitors. The LED screen as a component is produced by very few manufacturers. It is estimated by Samsung that in 2006 about 3% of all LCD monitors sold was equipped with LED backlight units. The LED technology promises improvements in many of the focus areas described in task 5, such as energy use during use phase and environmental impact from the PWB and electronic components. LED technology have, according to several monitor manufacturers, an energy saving potential of approximately 25 % compared to LCD technology. One main benefit of the LED products is that they do not use any mercury. Until now, LED monitors have not realized the improvement promised by the technology, they are expensive and does not use much less energy than ordinary LCD screens. Compared to LCD monitors the not yet mature LED technology also has a shorter lifetime.

6.2.2 Product improvements regarding energy use at computer system level

Computers are usually built of a lot of standard components, put together in order to provide a working system. The components have to be compatible and the system of components needs to be coordinated and handled in a proper way to give the system a good performance. To coordinate the system, computers are provided with operating systems.

There are several operating systems on the market. A majority of the PCs today use some version of Microsoft's operating system. Major competitors are Apple and Linux. For the general discussion here we select the operating system from Microsoft due to their dominant position on the market if an example is needed.

The complexity of the operating system is high and even if there is a clear candidate for a particular user due to company preference, software applications to be used etc. there are many versions to select between. Also, the process of adapting the operating system for particular processor technologies mean that in order to gain benefits from the newest low power processors the latest operating system need to be installed.

A general trend concerning new operating systems is that they require better hardware, faster processors, more RAM, better graphic cards and more hard disk space.

6.2.2.1 Improvements in the user pattern of the power management

An open industry standard was released in December 1996 called the Advanced Configuration and Power Interface (ACPI) that put the operating system in control over the power management of the PC and the monitor. For the "Sleep Mode" there are five states (S1 to S5) of which S3 and S4 are the most important in this discussion. The complete specification can be downloaded from ACPI and contains more than 500 pages. [ACPI]

There are several power save options supported by the operating system in a PC. The most common are "suspend to RAM" S3, "suspend to disk" S4 and "soft-off" S5 according to ACPI while the PC during normal operation is denoted S0 or "on-idle". There is one big difference in the states S3 versus S4 when it comes to the power consumption of the PC. If the PC turns off to the state "suspend to disk" everything from RAM is saved to the hard disk and when the PC wake up the information must be read back from the hard drive to the RAM. This can take several seconds, 30 seconds or more, and from a user perspective this is a long time. The result is that users often turn off (or prolong the settings) the power save functionality if suspend to disk is the available option. If the power save functionality is suspend to RAM the PC will start within a few seconds during wake up. Users generally accept this.

The reason why the option "suspend to RAM" was not generally implemented in PCs in 2005 was hardware related. Hardware that supports the option "suspend to disk" are cheaper than hardware supporting "suspend to RAM". PCs shipped today are generally supporting the suspend to RAM functionality.
Another improvement since 2005 is that many computers today are shipped with the power save functionality enabled and that only a few home users, less than 10%, change these settings. For office use the power management settings can be done remotely by the IT support. Those that do change their settings have good reasons for doing so and generally know what they do. One reason for changing the settings is the infrastructure the PC is connected to or the peripherals connected to the PC.

As an example of where the design of the PC in co junction with the infrastructure it is connected to influence the power management settings is the network connection.
Most PCs today are connected to a network of some sort. In the industry most companies have a corporate network that include servers for mail and storage etc. In the home environment it becomes more and more common that there are networks for sharing an Internet connection, a printer and additional storage. Peripherals in these networks are normally powered by an external power supply and these are the task for another part of the European project. The peripherals by themselves normally have no power save functionality but are included in the ACPI standard.

The network communication between the PC and the peripherals like routers, switches, modems an so on is done using the Ethernet standard. Regardless if the network is wired or wireless the basic standard for communication is Ethernet. There is one major drawback with this standard regarding the power save options for the PC. When a communication channel is established in an Ethernet network it often rely on the protocol DHCP (Dynamic Host Configuration Protocol). By this protocol the PC, the printer and all other equipments in the network are assigned IP addresses by the DHCP-controller. When the PC enters the power save mode the power to the network card in the PC is lost while the information regarding the IP address for the PC is saved on disk or in RAM. During wake up the PC can loose the connection to the network since the DHCP-controller noticed that the PC was no longer available (when the power to the network card was lost) but the PC still have the IP address since it was saved during shut down. This leads to a conflict between the PC and the DHCP controller and from a user perspective the PC is no longer on line. It is relatively simple to fix this by the "Control Panel" in Windows and "Repair" the connection but this task is not common knowledge by the average PC user. The only occasion when this is a large problem is when the network has a limited range of IP addresses. It is a task for the IT-organization to provide a good working environment in the network but for the average PC user this can lead to situations where computers are never shut off for fear of loosing their network connection.

It should be noted that this type of networking hassle usually is simple to solve for someone with a good understanding of the different technologies involved. For the average user this is not the situation. There is a general fear for changing anything in the setup of the computer if everything is working.

The situation will likely improve in the future due to more peripherals being compliant with the ACPI standard.
In the Business sector the energy consumption of the PCs can be managed remotely. Computer settings can be monitored remotely be the technology "Wake on LAN" and even set to the preferred mode (on) if users turn them off.
An improvement in the power management setting can be observed in the latest version of Microsofts operating system Vista. The help files associated with the settings are more user friendly and easier to understand.

Regarding settings, there are several opportunities for different modes of low power described above, and also for the times in inactivity until the low power modes are activated. Old time settings, such as 1 hour of inactivity and more until sleep is activated, usually keep the products in active mode during a full working day, while shorter times will activate sleep when the user go for a break, for a meeting or a phone call, thereby decreasing the amount of time in active mode to a large extent. The settings suggested by Energy Star 4.0 are:

- Monitors sleep mode set to activate within 15 minutes of user inactivity
- Computers sleep mode set to activate within 30 minutes of user inactivity.

Advantages: The advanced power management system in a modern PC can save a lot of energy, more than 60 %, when "the right" settings are used.

Disadvantages: None.

Problems: Hardware limitations discourage users from using the functionality. Consumer knowledge is limited. Complicated user interface with non-intuitive instructions. Today often disabled by somebody in the supply chain.

6.2.2.2 Optimum selection of the size of the internal memory

The size of the internal memory (RAM) in the PC is important because when the RAM is full the PC will swap information from the RAM to the hard drive. If a PC has too little RAM for normal applications the hard drive will have to work hard. The energy consumption will increase and the PC will be slow. A simple solution would be to purchase all the RAM that the computer design can handle but this is expensive, in particular if it is a high performance PC with a high bus speed. In addition, the purchase of additional RAM is a process that requires good understanding of the technical requirements for the PC and the installation requires the PC to be opened.

The energy consumption of the RAM memory as such is not the major issue even though a small amount of energy can be saved by using two 1 Gb RAM instead of four 512 Mb RAM to get 2 Gb memory size. More important is the impact an appropriate RAM size has on the performance of the PC for the desired task. A high end PC with insufficient RAM can perform as a medium PC with sufficient amount of RAM.

A potential customer generally has an understanding of the intended use of the home PC today but cannot make the appropriate selection without guidance. Furthermore the understanding of the possible future applications for the PC is impossible to foresee. Generally the buyer purchase the fastest PC the budget allow for without taking the amount of RAM that includes into account.

For the office use the intended applications are easier to foresee and the purchasing departments are often well educated and follow the market more closely.

Advantages: Optimum amount of internal memory make the PC perform better and consume less energy.

Disadvantages: Added cost of the PC.

Problems: Installing more memory in a PC requires the PC to be opened. Although relatively simple to do many home users do not identify their PC problems to the amount of installed RAM.

6.2.2.3 Impact of operating system regarding the hard drive

The problem with fragmentation of the hard drive is of importance for the energy consumption of the PC. The fragmentation occurs when the hard drive store files to the disk and does not find enough free space for the file but splits the file into smaller pieces on the drive. When the file is read back to the RAM the hard drive need to work harder since it need to perform more mechanical movements to gather all the pieces of the file which will slow down the computer and consume more energy.
The solution is to maintain the hard drive on regular intervals and perform a disk defragmentation.
There are at least two problems associated with this process. First, the user will not sense the need for disk defragmentation until the hard disk is so full of data that the performance of the PC will be poor. When the disk is full there will be no space available for the system to perform a defragmentation. Second, it requires an understanding of the internal processes in the computer that an average user does not possess.
With the new operating system Vista from Microsoft the disk defragmentation can be performed automatically which is one good step forward both from energy consumption point of view and for the users sense of performance. The PC will perform its task for a longer period of time and increase the lifetime.

One problem regarding this issue is that an upgrade of the operating system is costly and that older PCs usually don't support the new versions. Even if the PC will run on a new operating system all the hardware functionality will not be fully supported.

The energy savings due to disk fragmentation is low but it increases the lifetime of the PC, which is an important issue.

Advantages: If the operating system handles the fragmentation of the disk the PC will perform better and consume less energy.

Disadvantages: None

Problems: Manual disk defragmentation generally not performed due to limited knowledge of the problem. Upgrading a PC with new operating systems are often impossible due to hardware limitations.

6.2.3 Noise reduction of PCs

Since the Ecoreport tool does not handle noise, we need a separate discussion on the issue.

Background

The dominant noise emission standards world wide are the test standard ISO 7779 and the result is declared according to ISO 9296.

Statistics on Declared A-weighted sound power levels according to ISO 9296
The statistics declared here are based on measurements done on a limited number of desktop and notebooks computers made by TCO Development when developing the TCO labelling system for computers.
The declared Operating mode is when the hard disk drive is operating for at least 50% of the measured time and the fans are operating during 100% of the measured time.

<u>Desktop computers</u>

Sound Power levels measured 2003	
Idle	*Operating HDD (Hard Disk Drive)*
3.3 B (Mean value of 3 models tested)	4.0 B (Mean value of 3 models tested)
Sound Power levels measured 2004	
Idle	*Operating HDD*
3.8 B (Mean value of 3 models tested)	3.9 B (Mean value of 3 models tested)
Sound Power levels measured 2005	
Idle	*Operating HDD*
3.8 B (Mean value of 3 models tested)	3.9 B(Mean value of 3 models tested)

Notebook computers

Sound Power levels measured 2003	
Idle	*Operating HDD (Hard Disk Drive)*
2.9 B (Mean value of 15 models tested)	3.9 B (Mean value of 15 models tested)
Sound Power levels measured 2004	
Idle	*Operating HDD (Hard Disk Drive)*
2.1 B (Mean value of 3 models tested)	2.4 B (Mean value of 3 models tested)

These figures are very close to the sound levels given from the stakeholders in the IVF survey, where it was also stated that the monitors are quiet.

As a reference, the de-facto standard from "stadskontoret" in Sweden, which is often used for office equipment, recommend upper limits of declared A-weighted sound power level according to the following table:

Equipment for use in quiet office areas, classrooms, conference rooms and home environment.

Product	Lwad B, operating	Lwad B, idle
Desktop computers	5.0	4.5
Laptop computers	4.5	4.0

It is obvious that the products available at the market today are "enough" silent for ordinary office use. Still, if the equipment is to be used as a media centre, for example for musical use, the need for silence is even higher.

Best available technology regarding noise

The noise of a PC needs to be addressed taking the surrounding environment into account. In an office there are normally ventilation and possibly cooling systems that give a certain level of background noise. The noise level of the PC is disturbing if the added noise level is significant compared to the surrounding noise. For a Media PC where the location is the living room in a home the noise from the PC must be very low. Manufacturers have noticed this and since the noise is generated by the cooling fan a simple solution is to reduce the requirements for cooling. Reduced cooling requirements will lower the energy consumption from the fan. This, together with the battery life are the main driving forces for designing more energy efficient PCs.
The hard drive also generates noise. This is recognized by the manufacturers, leading to that new hard drives are generally more silent than the previous generation.
It is noted that the requirement for a silent PC is something specific for the market in the North of Europe. It is also here that the requirements for a PC with low power consumption can bee seen. For these reasons chip manufacturers and PC

manufacturers have selected the Scandinavian market as a test markets for new PC concepts.

A PC designed for low noise can reduce the noise level from 4.4 to 3.7 B (L_{WAD}) measured according to the standards ISO 7779 and ISO 9296.

Advantages: Reduced noise and reduced energy consumption are benefits for the user. Noise reduction by 0.7 B.

Disadvantages: None (perhaps higher cost).

Problems: None.

6.3 State-of-the-art at component level (prototype, test and field trial level)

The energy consumption of a PC is mainly divided into the following parts: the processor, the loss in the internal (or external) power supply, the motherboard including graphics processor and several other parts of the PC. For a desktop PC the processor will use approximately 40 % of the supplied power, 25 to 35 % of the power consumption will be lost in the power supply and the mother board will consume approximately 20 % according to information from the industry (under NDA). The rest will be distributed to the hard drives, fans etc. These numbers should be regarded as rough estimates and there will be variations in the actual numbers between different PC suppliers. Also, a typical Laptop PC differs regarding the actual distribution. It is, however, good to have these numbers as a background in order to keep the focus on the appropriate parts of the very complex device under investigation, the PC. Also note that the monitor is not included.

In the Task 4 report of this study the energy consumption for different parts are listed. The table below summarizes these results. These data are for PCs and monitors on the market 2005.

Table 106 Electricity use figure selected for the base cases.

Product cases ***Operational modes***	**Desktop**	**Laptop** (Screen on)	**LCD-screen**	**CRT-screen**
Idle (Watt)	78,2	32	31,4	69,5
Sleep (Watt)	2,2	3	0,9	1,5
Off (Watt)	2,7	1,5	0,8	1,5

Improvements can be made both in the hardware and in the user pattern of the PC. In many cases these improvements go hand in hand.

6.3.1 Improvements in energy use in the hardware of a PC (power management at component level)

Technologies, which are best from an environmental and energy efficiency point of view based on the findings in task 5, are described below, For hardware of PC, the main focus area for improvement is energy use during the use phase, but also the production of the motherboard including the processor, the power supply and the steel casing and the batteries are of importance. Batteries for laptops will be described separately.

6.3.1.1 Energy savings due to the type of processor

One major improvement in the PCs supplied today is better processors, such as the multi core processors. Multi core processors are available from several manufacturers. The basic idea is that in a multi core processor several tasks can be performed in parallel with each other instead of one task after the other. In principle a dual core processor is as fast as a single core processor with twice as high clock frequency. Since the energy consumption is proportional to the clock frequency the energy consumption could be reduced by half in a dual core processor. The reality is not that good but a substantial improvement can be seen in the multi core processors delivered today. Another benefit with multi core processors is the ability to shut down or reduce the clock frequency of one or more of the cores for specific tasks. This can be useful for instance when the PC shall perform only one simple task like streaming a video or audio file. For such a task the PC can be operated in a mode with only one core running.

Of course, the operating system and the applications need to be designed so that they make use of the capacity of the processor design.

In data provided by computer and processor manufacturers a decrease in energy consumption of more than 60 % can be seen for a PC processor of the multi core type compared to a single core processor if the operating system supports optimised use of the multi core processor..

It would be interesting to compare two PC that have identical performance from a user point of view where one PC would be based on a single core processor and the other based on a multi core processor. It would highlight the difference in energy consumption and the difference in price. This can however not be done since such PCs are not found of the shelf.

The consumer price for a single core processor of 2005 intended for a Desktop PC was 40 Euro and for a Laptop PC 55 Euro respectively. When a dual core processor have a high market penetration the consumer price for the Desktop processor will be 50 Euro and for the Laptop PC 70 Euro.

One challenge is to educate the consumers that the processor clock frequency is of limited importance for the "feel" of the computer capacity. Multi core processors with relatively low clock frequency are as good or even a better alternative for most practical applications. The facts that it saves energy and requires less cooling are additional benefits.

Advantages:	Low power consumption for a dual core processor. Compared to a single core processor 60% less power consumption.
	Reduced noise.
Disadvantages:	New technology, 20% more expensive.
Problems:	User awareness of the different alternatives is limited.

6.3.1.2 Energy savings by adaptive intensity of processor use

One method of reducing the power consumption of a PC is to reduce the intensity of the processor when the needed capacity is reduced. It can for example be

achieved by reduced clock frequency or reduced voltage, sometimes called throttling. This was often applied in Laptop PCs in order to increase the battery time. For instance, the processor speed can be reduced when the graphics card is working hard.
This technology is introduced into desktop PCs due to the problems of heat generation in the processor. As much as 40 % of the power consumption of the processor can be saved if adaptive clock frequency is used. Of course, the savings depend to a large extent on the user pattern and what applications the PC runs.

Naturally, the technology of adaptive clock frequency could also be adapted for the processor at the graphics card but this is not implemented today.

Advantages: Reduced power consumption by 40 %.

Disadvantages: None.

Problems: None.

6.3.1.3 Energy savings of the motherboard

When data is transferred between the hard drive, the optical media (CD or DVD), the RAM etc. and the processor the communication runs by the internal data bus on the computers motherboard. The data rate is controlled be the clock that controls this data bus.

Over the years there has been a similar evolution of the data bus speed as for the processor speed. An indication of this can be found in the range of accepted bus speeds that the internal memory can handle, the RAM. The data bus clock frequency today can range from 266 MHz to 1033 MHz. (The steps are: 266, 333, 400, 550, 667, 800, and 1033 MHz today).

The situation today is that a high end PC usually has high frequency both for the processor and for the internal bus. The bus speed is more related to the particular processor used and cannot be selected arbitrarily.

Depending on the application the bus speed can be more important than the processor speed for the experienced performance of the PC. However, the bus speed is often neglected in the marketing of the PC. A user can experience that a PC with a low clock frequency of the processor but a high bus speed is faster than a PC with a high clock frequency and a low bus speed. Thus, a consumer could purchase a PC with a relatively slow processor and save both money and energy if the overall performance of the PC meets the consumer needs.

Advantages: Optimized PC for the intended application.

Disadvantages: Not an available option.

Problems: User awareness of the alternatives is limited.

6.3.1.4 Energy savings by the design of the power supply

The efficiency of the main power supply can be designed to a high standard. With modern technology of switched power supplies the efficiency can be as high as 90%. One drawback of an efficient power supply can be the emission of unwanted signals in the power line, which can be solved by the use of filters. This, however, increase the cost of the power supply. The requirements of the power supply are recognized by for instance Energy Star and manufacturers are compliant with these standards. There is an initiative from the industry to build more efficient internal power supplies called “80-plus”. These requirements state that the power supplies shall have an energy efficiency of greater than 80 % at 20 %, 50 % and 100 % of rated load with a true power factor of 0.9 or greater. [80-plus]. A typical PC with a power consumption of 80 W in idle mode can reduce the needed power by 20 % using an “80-plus” power supply compared to an old (2005) power supply with 65% efficiency, for as little as 5 Euros extra cost. The stand by power consumption of such a power supply is less than 3 W.

For laptops, using external power supplies, there are high efficient power supplies available with an efficiency of 84%. These comply with Energy Star criteria for external supplies. The assumption is that the saving of 20% is the same, since the efficiency of external power supplies 2005 was better than the internal power supplies for desktops.

Advantages: Reduced energy consumption by 20 %.

Disadvantages: 5 Euro higher cost.

Problems: None.

6.3.1.5 Energy savings by the design and selection of a hard drive

Flash drives

There are alternatives to a conventional hard drive in the form of Flash drives. The Flash memory is common in devices like USB memory sticks, memory cards, MP3 players etc. From a technical point of view it would be possible to build a PC without a hard drive and rely on Flash memory for storage but this option would be expensive. Currently the cost for the Flash memory is at least ten times as high as the same capacity for an ordinary hard drive.

The power consumption of the PC could be reduced by the few Watts that the hard drive consumes with this alternative.

The real benefit of a solution with a flash hard drive is the time it takes for the PC to start both from states S4/S5 and to boot. This could dramatically change the user pattern of a PC due to power management being enabled.

Advantages:	Reduced noise since no fan is required for the hard drive. Reduced energy consumption by 7 W. Increased use of power management.
Disadvantages:	Higher cost.
Problems:	Not available.

Hybrid Hard Disk

An intermediate step between the ordinary hard disk and a Flash disk is the hybrid disk that combines the two technologies. A flash memory with the size of minimum 50 Mb is used in combination with the ordinary hard drive that allow the hard drive to be spun down when not in use. The flash memory is used also when the disk spins up again and works as a Cache memory for the drive.

The power consumption of the PC can be reduced since the hard drive can be spun down more often with this alternative.

Another benefit of a solution with a hybrid hard drive is the time it takes for the PC to start both from states S4/S5 and to boot will be only a few seconds. This would support the use of power management.

The hybrid hard disk technology is supported by Windows Vista.

Advantages:	Reduced noise. Reduced energy consumption.
Disadvantages:	Higher cost.
Problems:	Requires support by the operating system.

6.3.1.6 Energy savings by other cooling technologies

The common cooling technology in a modern PC is by careful design and by a fan that force air to flow through the cabinet. Often the cooling fan is temperature controlled particularly for Laptop computers.

Alternative systems for cooling are available such as liquid cooling but the indications today are that the technology is not mature and that the pull from the market is not here. It remains as a technology for enthusiasts for the moment.

The main benefit of the liquid cooling is not the energy savings but the fact that the processor can be kept at a very low temperature. An additional benefit is that the system of liquid cooling can be quiet.

Advantages:	Reduced noise.
Disadvantages:	High cost.

Problems: Not a mature technology.

6.3.2 Reducing the environmental impact from board assembly

For all the products in the study, the focus areas found in task 5 included production of PWB and components (board assembly). Board assemblies include a lot of scarce and/or hazardous substances, which can be minimized by following the trend towards smaller and smaller components. The bonding between the components and the PWB is also of great importance, both because of the content of scarce materials as Sn, and because the bonding methods often limit the opportunity to use smaller components.

The products in this study are all lead-free due to the present legislation. The most common lead-free solder used today is the SnAgCu alloy. Even if lead is banned there is still an environmental impact from the new solder alloys Sn and Ag. If alternative electrical interconnection technologies could be used the amount of solder would be reduced. The relative material consumption for different electrical interconnect technologies are compared in the Figure below.

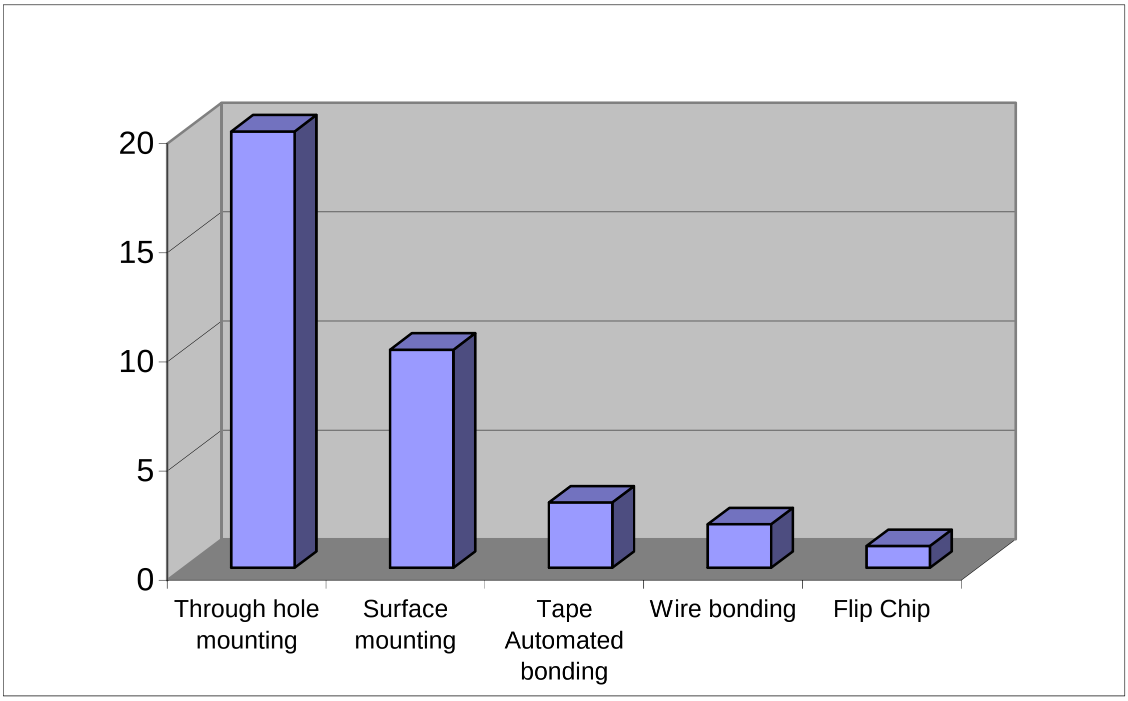

Figure 26 The relative material consumption (mg solder/bond) for different electrical interconnect technologies [Bergendahl et al. 1995]

One example of a new technology is the concept for 3-D packaging. In this technology several chips are stacked on top of each other and wire bonded to a carrier. The whole stack is then packaged leading to a small footprint (area on the PWB).

The production of PWB´s follows the different legislations concerning both environment and the applicable work safety regulations. The general trend is to avoid as many problematic chemicals and processes as possible without jeopardizing the reliability of the product. The use of halogen free flame-retardant in polymers in PWBs reduces the environmental impact. The RoSH directive have no direct influence, as the halogen flame-retardant used in PWB are not included in the legislation. However there are several new halogen free alternatives both for epoxy used in the electronic components and for the epoxy used in the printed circuit boards.

6.3.3 Improvements in Monitors for PCs

One general comment regarding monitors for PCs is that market forces drive manufacturers to design for high brightness while most users set the brightness to a level of 125 to 150 Candela for convenient viewing. The maximum brightness of many monitors is in the range 250 to 300 Candela. The monitors are often designed for high efficiency at the maximum brightness leading to decreased efficiency during normal use.

Another issue is the “screen savers”, which make the monitors use high power even when not in use.

6.3.3.1 LED backlight for LCD Monitors

There is many advantages whit changing the fluorescent lamps to LED backlights, such as it will improve the LCD's colour saturation capabilities, contrast and black levels. The backlight unit, (BLU), will contain no mercury. The lifetime of the BLU and thereby of the monitor could increase to up to 100 000 h with little or no degradation. [CI Displays]. LED BLUs is believed to be able to reduce the energy consumption when the technology matures. Compared with ordinary LCD screens the energy consumption could be reduced by 25 %. It is also possible to dynamically dim the backlight in any part of the screen and thereby improve the black level and energy consumption.

The LED backlight for LCD displays will increase the quality of the image, prolongs the lifetime of the monitors and has a potential to save energy.

Advantages:	No mercury in the screen. Power consumption can be reduced by 25 %. Longer Lifetime estimated when mature.
Problems:	Not yet a mature technology giving a high price and currently too high power consumption.

6.3.3.2 Possibility to take the lamps out of the LCD for End of Life treatment

Make the lamps containing mercury easy to disassemble from the rest of the LCD screen in order to take care of the mercury in a proper way in the End of Life treatment. This means that the housing must be possible to open and the connections have to be easy to take apart in order not to damage the mercury lamps. Gluing and welding must not be used to bond parts and make removal of the lamps complicated. [TCO´03]

The amount of Mercury in a normal 17" LCD monitor is 8 micrograms according to TCO statistics.

Advantages: Gives the opportunity to treat the lamps containing mercury in a proper way and thus minimising the mercury emissions from LCD.

Disadvantages: Can perhaps make the product slightly more expensive, by hindering welding and gluing.

6.3.4 Minimizing the content of flame retardants in plastics

The ecoreport tool does not explicitly handle flame retardants, and they are therefore not pointed out as focus areas in task 5, but they are still of environmental importance for all the products in the study.

Even if RoHS is now applied to this kind of equipment, and some flame-retardants (polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)) are nowadays forbidden, there are still some hazardous substances left in the products. The substitute flame-retardants are often quite new and not enough investigated, and may emerge as environmentally problematic in the future. For a product such as an LCD screen, there are often about 2 kg plastics that can contain up to 40% flame-retardants. These flame-retardants have to be considered as a quite considerable environmental risk even if this risk cannot be quantified today.

There are ways to minimise the use of flame-retardants in plastics in order to minimise the emissions of hazardous substances. One possibility is to exchange the plastics into hard wood, which is much more flame retardant than plastics [TCO´03] [project Heatsun], other possibilities are to reduce heat generation or to use metal housing.

Advantages: Minimise the emission of hazardous substances from the products. Design might also become beneficial, since many people find wood more beautiful than plastics.

Disadvantages: Wood is not that easy to form freely to different geometries, and thus a change to wood can make the product more expensive. Metal is heavy and difficult to give a free geometry.

6.3.5 Change to renewable plastics

The plastics were of some importance when discussing the focus areas in task 5, even if it was not the most important issue. All the products in the study are containing rather big volumes of plastics, and therefore a discussion on renewable plastics can be of interest for all of them.

There is an ongoing discussion on the use of non-renewable materials, including plastics (made of oil). New technologies are developed in order to make these materials renewable. One such technology is to use biofiber-reinforced bioplastics. The biofiber can for example be made of linen, kenaf or cellulose. Plastics can for example be made through a polylactid acid polymerisation, from corn to polymer. There are already mobile phones on the market using these technologies. However, the environmental qualities of bio-plastics have not yet been adequately documented so the potential improvement cannot be quantified.

Advantages: Going from non-renewable to renewable materials. Can also be biodegradable.

Disadvantages: The lifetime of the renewable polymers are sometimes less than those of non-renewable polymers. Not yet a mature technology. Environmental qualities of bio-plastics are not yet fully documented.

6.3.6 Batteries for Laptops

Batteries for laptops are one of the focus areas described in task 5. Batteries used for Laptops are mainly of the Lithium-ion type, even if also Lithium-polymer batteries are used. The difference between the two of them is that the electrolyte in the latter is bound in a polymer. One of the important characteristics for batteries of mobile equipment is energy per weight, where both these types are good solutions. They both also have a rather low self-discharge rate. Another important quality of rechargeable batteries is how they behave when not fully charged. Old time batteries such as Ni/Cd have a memory effect, making them less effective after “bad” charging habits and are therefore no longer used for laptops. Regarding the environmental impact, there are a few main things to bear in mind:

- Energy efficiency. How much of the charger energy goes into the battery for storage, and out to be used.
- Aging. Most rechargeable batteries loose their charging capacity over time, often the capacity (possible use time of the equipment) can decrease by 50% during the first year, depending on battery quality, ambient temperatures etc. Many times, laptop computers are exchanged due to insufficiently working batteries, because new batteries are often very expensive to buy.
- Toxic substances. Li-ion and Li-polymer batteries contain some toxic substances, for example lithium itself and organic solvents, and needs to be taken care of in the end of life treatment.

- Risk for explosions or fire. Li-ion and Li-polymer batteries self ignite and can cause an explosion at temperatures of 180-200 degrees Celsius. This can happen when overcharging the batteries or if a short circuit occurs.

6.3.6.1 Make it easy to remove the batteries

In order to improve the end of life treatment, it is of importance to make the batteries easy to remove from the product. That will stop the toxic and dangerous (explosive) substances from the batteries to spread in the environment. To fully utilise this option, some kind of take back/circulate system for old batteries is needed.

6.3.6.2 Effective charging methods

There are always energy losses in the charging process. In order to minimise that, the charging process should be as effective as possible. In docking units for laptops, the charging is often always on, which gives losses all the time, even if the battery is fully charged. The charging should preferably stop when the battery is fully charged, because this will reduce charging losses and extend battery service life. Of importance is a good instruction to the user, in order to optimise the charging methods used.

6.3.6.3 Minimise battery aging

Because of aging, battery capacity is often reduced by half in only one year. The aging starts directly after manufacturing, and it is therefore of importance not to store batteries before they are used. The aging is also very much depending on the ambient temperature. The lower the ambient temperature (but not frozen) the longer battery life! Lower temperature can be achieved by good cooling of the product, but also by giving the user instructions and possibility to disconnect the batteries and put them in a cooler place than in a hot computer when the laptop is connected to the mains.

6.3.6.4 New battery chemicals (Best Not Yet Available Technology)

There is a development of new chemicals for batteries ongoing. Much of that development aims at giving safer batteries (less risk for explosions or fire) but also in order to make them cheaper or giving higher energy capacity per weight. These new chemicals are for example, Lithium-Mangan-Oxide-Spinell ($LiMn_2O_4$), which is safer, but have less energy capacity and Ion-Phosphate ($FePO_4$), which is cheaper than today's chemicals. Another solution is Zinc-air batteries (today used in hearing aids), where oxygen in the surroundings is used as one of the chemicals in the process, making the need to carry all the chemicals less. There is also an ongoing development of new electrolytes in order not to use the toxic organic ones.

6.3.6.5 Fuel cells (Best Not Yet Available Technology)

Fuel cells generate electricity from an electrochemical reaction, in which oxygen and a fuel (eg. hydrogen) combine to form water. There are several different types of fuel cells but they are all based on a central design. Direct methanol fuel cells (DMFC) draws hydrogen from liquid methanol. This type of fuel cell is the most appropriate for PC laptop applications, but has not so far reached the market in any substantial volumes.

6.3.7 Best Not Yet Available Technologies

6.3.7.1 OLED Displays (organic light-emitting diode)

"OLED displays stack up several thin layers of materials. They operate on the attraction between positively and negatively charged particles. When voltage is applied, one layer becomes negatively charged relative to another transparent layer. As energy passes from the negatively charged (cathode) layer to the other (anode) layer, it stimulates organic material between the two, which emits light visible through an outermost layer of glass." [Kodak 2006]

At present OLEDs are used in small and relatively short-lived portable colour video displays such as mobile phones and digital camera screens.
Large-screen colour displays have been demonstrated, but their life expectancy is still too short, especially for the blue colour, < 1000 Hrs, to be practical.
The estimate from the industry is that full size computer displays with the OLED technique is still 4-5 years away.

The plastic, organic layers of an OLED are thinner, lighter and more flexible than the crystalline layers in an LED or LCD. OLEDs are brighter than LEDs. Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layers of an LED, the conductive and emissive layers of an OLED can be multi-layered. Also, LEDs and LCDs require glass for support, and glass absorbs some light. OLEDs do not require backlighting like LCDs and consumes therefore much less power. OLEDs produce their own light, so they have a much wider viewing angle. The response time for OLEDs is faster than for LCD displays. OLED can produce a true black and infinite contrast ratios, and have the potential to be easier to produce and can be made to larger sizes.

Disadvantages with the OLED technique

Lifetime for OLED is still quite short. While red and green OLED films have long lifetimes (10,000 to 40,000 hours), blue organics currently have much shorter lifetimes (only about 1,000 hours). Manufacturing processes are expensive in this stage of the development and water can easily damage OLEDs.

The OLED technique has the potential to show both moving and still images with much higher quality and with much less energy consumption than todays LCD monitors, if the lifetime and manufacturing problems are solved. Currently it is unclear if this technology will enter the market for PC monitors.

Advantages: Low power consumption and better imaging quality.

Disadvantages: Not tested as a monitor in larger scale for a PC yet.

6.3.7.2 Solid state Lasers for projection systems and backlights for LCD Monitors

Both Mitsubishi Digital Electronics America, Inc and the also US based company Novalux has developed solid states Lasers for big screen televisions based on the back projection technique. They have both demonstrated working television prototypes: Mitsubishi in Huntington Beach (USA) in April 2006 and Novolux together with the Australian company Arasor in Australia in October 2006. Novalux has expressed an intention to develop the technique for use in computer monitors. Both Mitsubishi and Novalux /Arasor have stated that big screen televisions with the Laser technique will be commercially available in the end of 2007. Other companies developing Laser units for use in displays are: Coherent, http://www.coherent.com/ and Principia LightWorks, www.principia-lightworks.com.

Advantages whit Lasers
Lasers have a very large color gamut, and high brightness compared to fluorescent lamps or LCD backlights. They have high power conversion efficiency and are long lived. The solid state Laser units have the potential to be relatively inexpensive to manufacture.

The solid state Laser will take the quality of the images a big step forward. They will prolong the lifetime of the monitors and they are also power efficient.

Advantages: Low power consumption and high imaging quality.

Disadvantages: Not yet tested as a monitor in large scale for a PC.

6.3.7.3 Electronic Paper, e.Ink

The e.ink technology gives the same feeling as viewing a paper. As with paper it relies on reflected light and has no backlight. The brighter the incident light the better the reading conditions. The technology is based on proprietary electronic ink applied on a circuit board. The appearance of the ink is changed by an electric field. Products with this display technology in black and white are available on the market and consist of devices such as e-book readers, USB-memories with a display etc. Colour prototypes are available.

One benefit with this display technology is the low power consumption and that it only consumes power when the image is changed. Another benefit is that the electronic ink can be applied on virtually any surface with an electric circuit. The surface can even be flexible.

The e.Ink corporation believe that the technology will enter the market for mobile phones and GPS receivers in addition to the existing market for e-book readers. In the future the technology can be used for a PC monitor.

Advantages: Low power consumption.

Disadvantages: Not yet tested as a monitor in large scale for a PC.

6.4 State-of-the-art of best existing product technology outside the EU

The manufacturers of computers and monitors act on a global market and most of the hardware is manufactured outside the EU. The technologies described above are covering the global market.

6.5 References

- 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.
- Deep interviews with computer, monitor and component manufacturers under non-disclosure agreements to get information about best available technologies, improvements and their improvement potential. The number of companies interviewed was 10 and the number of persons 27.
- TIAX. Energy Consumption by Office and Telecommunication Equipment in Commercial Buildings, Volume II: Energy Savings Potential. TIAX Reference No. D0065-11.08, December 2004.
- ACPI (ADVANCED CONFIGURATION AND POWER INTERFACE SPECIFICATION). Revision 3.0b, October 10, 2006. http://www.acpi.info/spec.htm
- 80 Plus, www.80plus.org
- CI Displays, www.cidisplays.com
- Kodak 2006 www.kodak.com
- TCO´03 Displays Flat panel Displays, version 3.0
- Project Heatsun, www.projectheatsun.com
- Energy star list of products “Final computer dataset 10-20-06”
- Handbook for design of environmentally compatible electronic products. A daily tool for designers *Bergendahl et al 1995 IVF number 95819*
- Stadskontoret TN26-61 Acoustical noise emission of Information Technology Equipment.
- ISO 9296 The international noise emission declaration standard for information technology (IT) equipment.

7 Improvement potential

Task 7 consists of identifying the design improvement options, quantifying the influence they have on the environmental focus areas described in task 5, and rating them in terms of Life Cycle Costs (LCC) for the consumer. The option or combination of options with the Least Life Cycle Costs (LLCC) should be pinpointed. Key technical improvement options have been identified in task 6 based on the focus areas described in task 5. The analysis in task 7 will focus on key options from an energy-saving point of view since that is the main focus area described in task 5 for all the products.

7.1 Options

7.1.1 Power management

As stated in Task 6, the problem with power management is that so few people use it in a proper manner. The idea is simple, the PC should only use energy when actually needed. Many PCs are today shipped with the power management feature enabled, but some users switch the feature off for various reasons discussed in Task 6. Improvements in power management are relevant to all eight bases cases as defined in Task 5.

Estimations on potential savings from using power management vary a lot. In the calculations is assumed 50% savings in the idle power state, (according to the settings suggested in task 6) i.e. the idle time is decreased by 50% and the sleep time is increased by the corresponding number of hours. This leads to a corresponding decrease in electricity consumption.

Although power management is mainly a user attitude issue, there are also hardware related problems. Some peripherals lose contact with the network when the computer falls asleep, the speed of wakening up from sleep mode could be shortened by technology like flash memory etc. However, as these are indirect effects, no changes in bill of materials are assumed.

7.1.2 The processor

The processor in a 2005 desktop computer takes roughly 40% of the energy, see Figure 8 below.

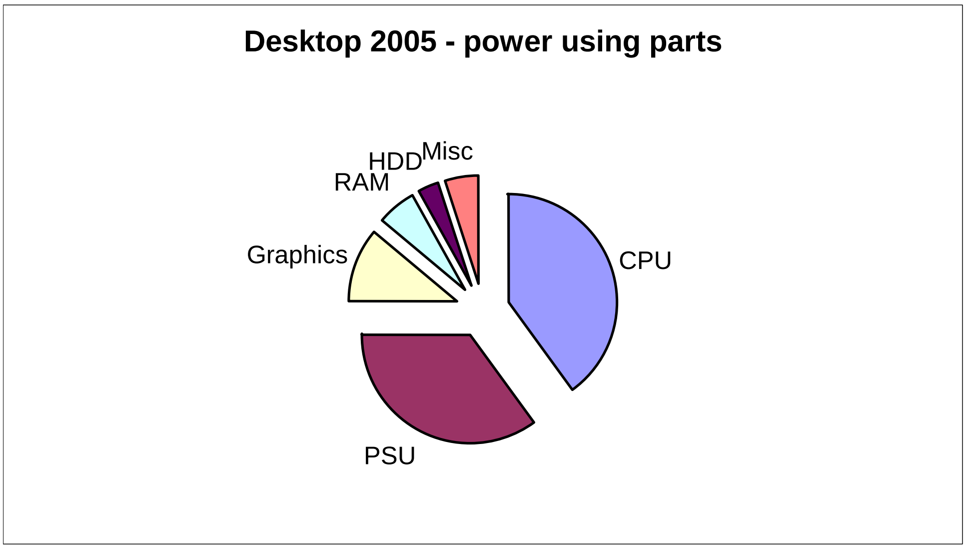

Figure 27 Distribution of power use in desktops from 2005.

In a laptop, which also has an LCD-screen, the processor uses around 20% of the energy, se Figure 9 below.

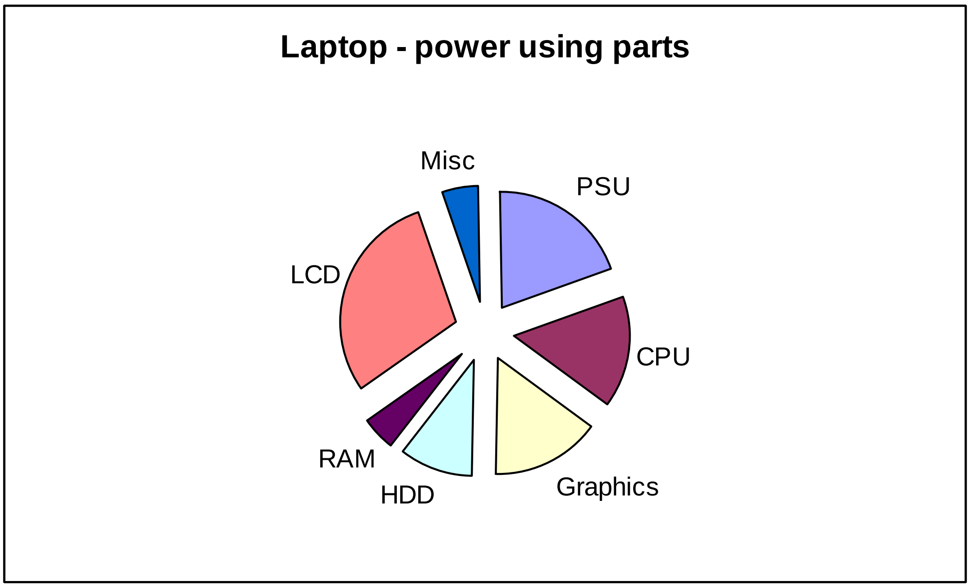

Figure 28 Laptop-power using parts.

Dual core technology, offers 60% savings in processor energy use, see Task 6. Processor improvements are only relevant for desktops and laptops, not for monitors. In the calculations is assumed 0,60*0,40=24% energy savings on desktops, and 0,6*0,2=12% savings on laptops (in the use phase).

The price difference between single core and dual core when the technology has matured a bit more than it had 2007, is expected to be 10 Euro for a desktop processor and 15 Euro for a laptop processor. See Task 6 for a more detailed discussion on processor price developments.

There are no visible or weight changes in a dual core chip compared to a single core chip. Thus it is assumed that the BOM does not change, and that the environmental impact from the production phase is not changed.

7.1.3 Adaptive processor intensity

One method of reducing the power consumption in a desktop is to reduce the intensity of the processor e.g. by reducing the clock frequency or voltage when the need for capacity is reduced. This is often applied in laptops in order to increase the battery time. As much as 40 % of the power consumption of the processor can be saved if adaptive intensity is used. Adaptive intensity is only relevant for desktops. In the calculations is assumed 0,40*0,40=16% energy savings on desktops (in the use phase).

No extra cost is foreseen for this option in the longer term. Nor should it entail significant changes in the BOM and thus the environmental impact from the production is not changed.

7.1.4 Power supply units (PSU)

By using a switched power supply designed to high standard, the power supply efficiency can be increased from currently 65-70% (2005) to 80% or even 90%. It should be noted that Energy Star 4.0 requires “80-plus” power supplies. For further description of the technology, see Task 6.

Power supply units are relevant to all eight bases cases as they are focus areas defined in Task 5.

As described in Task 6, there is no evidence that increasing the efficiency would lead to changes in the weight of the power supply, i.e. no changes in the BOM is assumed and thus the environmental impact from the production is not changed. This assumption is supported by the Lot 7 study [2007] on external power supplies.

An “80-plus” internal PSU for desktops and 84+ PSU for laptops will reduce idle mode power with approximately 20%, see Task 6. Reductions in sleep and off modes are assumed to be more related to the threshold levels in Energy Star 4.0 for computers and Energy Star 4.1 for displays than to percentage reductions. See Table 98 below.

Table 107 Energy Star 4.0 requirements for computers and Energy Star 4.1 for displays on power in sleep and off modes.

Base-case / Mode	**Sleep (W)**	**Off (W)**
Desktop, office and home	4	2
Laptop, office and home	1,7	1
Displays, office and home	2	1

The approximate additional cost for an “80-plus” PSU for desktops or “84-plus” for laptops is 5 Euros, according to several computer manufacturers, see Task 6.

7.1.5 Using LCDs instead of CRTs

This option, which is already being implemented by private and public consumers to a large degree, is already quantified in the base case calculations. It includes of course quite large changes also in the bill of materials.

7.1.6 Using laptops instead of desktops

This option is to an extent already being implemented by private and public consumers, see Task 2.2.2.1. It includes quite large changes also in the bill of materials. This option is of course only relevant to desktops.

If no external display is needed for the laptop, then an LCD-display should be added to the desktop to get a fair comparison. This situation is assumed realistic in home use.

If an external display is needed also for the laptop, laptop values are adjusted to account for not using the internal LCD-screen. This means lowering the idle power with 10 Watts, see Task 4.3.3.2. This situation is assumed realistic in office use. Since both setups require an LCD-display, the display can be disregarded in the comparison.

Another issue can be that laptops (without extra screen, keyboard and mouse) cannot offer the same work environment, in terms of ergonomics, as desktops.

7.1.7 Hybrid hard disks

A hybrid hard disk is a hard disk combined with quite a large flash memory. The advantage being very quick wake-up times from sleep mode, hibernation mode and fast boot time. This technology could therefore help in implementing power management savings. Since the hard disk consumes a few watts, also some direct energy savings are possible. Early 2007, the hybrid hard disk was not yet available on the market and no cost information was available.

7.1.8 LED backlight screen

LED screens are quite new, and came to the market recently and there are very few manufacturers producing LED screens today. The technology have a future potential to reduce the power consumption for the screen by approximately 25% compared to an average LCD backlight screen. For monitors the power in idle mode is reduced by 25 % in the calculations. For Laptops, the screen uses approximately 30% of the energy in idle, which gives a 7.5 % reduction in power if LED backlight is used. No changes in the BOM are assumed (the only obvious change in BOM is the eliminated mercury content, which can not be handled in the Ecoreport tool) and thus the environmental impact from the production is not changed. An extra cost for LED compared to LCD screens is assumed to be 50€ in the calculations. The cost today is higher, but will probably due to the rapid development decrease.

7.2 Impacts and costs

Table 99 gives two environmental indicators and LCC per product for all eight bases cases. Most of the improvement options will not lead to changes in the Bill of material (BOM) and thus the environmental impact from the production is not changed.

These improvements thus concern energy use in the use phase, where total primary energy and/or total greenhouse gases, can represent any of the other impact indicators.

Table 108 Impacts and costs per product for the base cases.

Base cases Life cycle impact/cost	Desktop office	Desktop home	Laptop office	Laptop home	LCD in Office	LCD at home	CRT in Office	CRT at home
Total Energy, GER (MJ)	16165	12529	7200	4995	7231	4473	14515	8403
Greenhouse Gases (kg CO2eq)	761	603	348	251	336	216	657	390
Product price (Euro)	620	520	1242	990	201	201	73	73
Electricity (Euro)	163	119	70	43	73	39	159	85
Repair & maintenance costs (Euro)	117	117	118	118	0	0	0	0
Total Euro	900	756	1430	1151	274	240	232	158

7.2.1 Power management

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement that power management in average reduced the active/idle time with 50%. Since there is no cost involved, only decreased electricity use, the environmental impact and the LCC is decreased for all base cases.

Table 109 Impacts and costs for implementing power management 50% less active/idle time.

Base cases / **Life cycle impact/cost**	**Desktop office**	**Desktop home**	**Laptop office**	**Laptop home**	**LCD in Office**	**LCD at home**	**CRT in Office**	**CRT at home**
Total Energy, GER (MJ)	10166	8363	4973	3811	4498	3112	8422	5369
Greenhouse Gases (kg CO2eq)	500	421	250	200	217	157	391	258
Product price (Euro)	620	520	1242	990	201	201	73	73
Electricity (Euro)	90	68	43	29	40	23	85	48
Repair & maintenance costs (Euro)	117	117	118	118	0	0	0	0
Total Euro	827	705	1403	1136	241	224	158	121

7.2.2 Improved processors

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to implement dual or multi core processor technology. The environmental impact is decreased for all relevant base cases. The LCC is lower for desktops and higher for laptops, compared to the base-cases due to that the energy use for desktops is higher, and therefore the savings larger.

Table 110 Impacts and costs for implementing improved processors.

Base cases / **Life cycle impact/cost**	**Desktop office**	**Desktop home**	**Laptop office**	**Laptop home**
Total Energy, GER (MJ)	13085	10392	6554	4701
Greenhouse Gases (kg CO2eq)	627	509	319	239
Product price (Euro)	630	530	1257	1005
Electricity (Euro)	126	93	62	39
Repair & maintenance costs (Euro)	117	117	118	118
Total Euro	872	740	1437	1162

7.2.3 Adaptive clock frequency

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to use adaptive clock frequency in desktops. The environmental impact (and the electricity bill) can be reduced and the LCC will decrease correspondingly since no extra cost is assumed.

Table 111 Impacts and costs per product for implementing adaptive processor intensity.

Base cases / **Life cycle impact/cost**	**Desktop office**	**Desktop home**
Total Energy, GER (MJ)	14080	11082
Greenhouse Gases (kg CO2eq)	670	540
Product price (Euro)	620	520

Base cases Life cycle impact/cost	Desktop office	Desktop home
Electricity (Euro)	138	101
Repair & maintenance costs (Euro)	117	117
Total Euro	875	738

7.2.4 Improved power supplies

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to use "80-plus" power supplies for desktops and "84-plus" power supplies for laptops. Since there is very little extra cost involved, the environmental impact and the LCC are decreased for all base cases.

Table 112 Impacts and costs for implementing 80+ power supplies.

Base cases Life cycle impact/cost	Desktop office	Desktop home	Laptop office	Laptop home	LCD in Office	LCD at home	CRT in Office	CRT at home
Total Energy, GER (MJ)	13542	10610	5895	4119	6102	3910	11942	6994
Greenhouse Gases (kg CO2eq)	647	519	291	213	287	192	545	329
Product price (Euro)	625	525	1247	995	206	206	78	78
Electricity (Euro)	131	96	54	32	59	32	127	68
Repair & maintenance costs (Euro)	117	117	118	118	0	0	0	0
Total Euro	873	738	1419	1145	265	238	205	146

7.2.5 Using LCDs instead of CRTs

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to use LCD-screens instead of CRT-screens. The environmental impact (and the electricity bill) can be approximately halved, but the LCC will increase due to higher price for LCD-screens.

Table 113 Impacts and costs per product for using LCDs instead of CRTs.

Base cases Life cycle impact/cost	LCD in Office	CRT in Office	LCD at home	CRT at home
Total Energy, GER (MJ)	7231	14515	4473	8403
Greenhouse Gases (kg CO2eq)	336	657	216	390
Product price (Euro)	201	73	201	73
Electricity (Euro)	73	159	39	85
Repair & maintenance costs (Euro)	0	0	0	0
Total Euro	274	232	240	158

Since the BOM is changed, the figure below is included to show that also the other impact categories are decreased when using LCDs instead of CRTs. Figure 10 shows that this is true except for persistent organic pollutants that show a small increase. Since the greenhouse gas difference for this option is smaller in homes than in offices, the above statement will also hold true in offices.

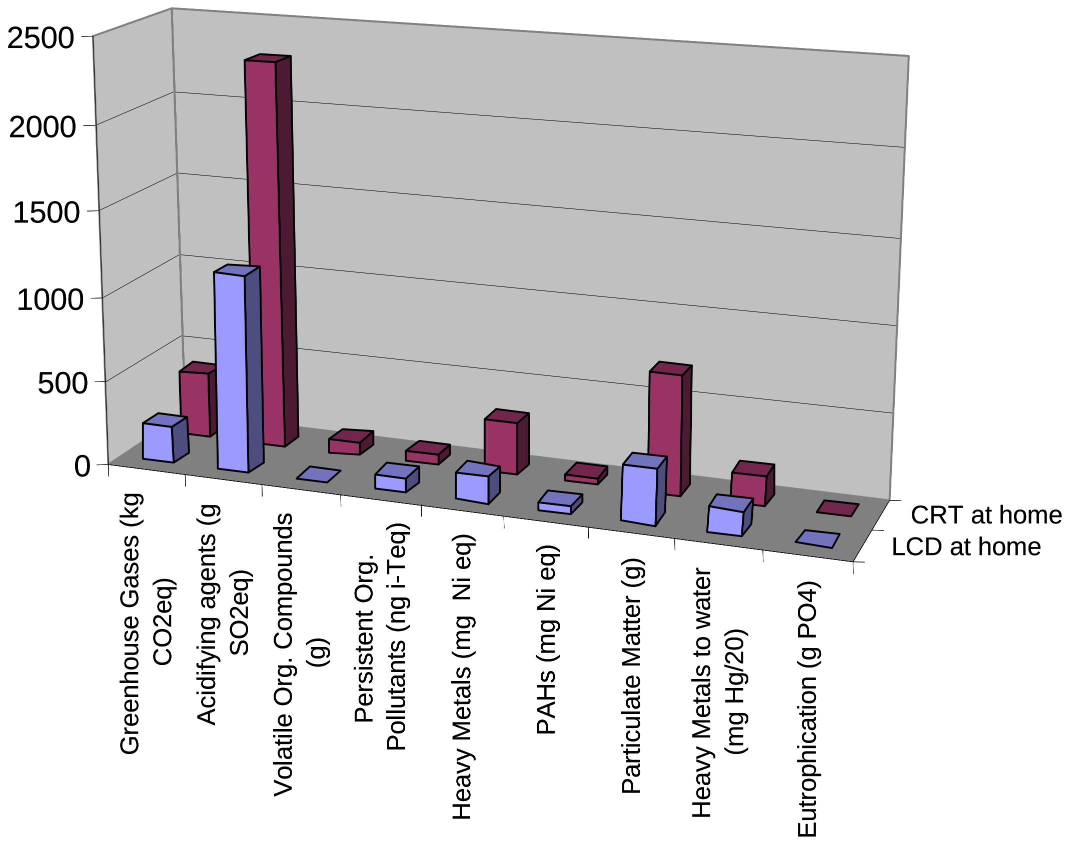

Figure 29 Environmental impact when changing from CRT to LCD.

7.2.6 Using laptops instead of desktops

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to use laptops instead of desktops. The environmental impact (and the electricity bill) can be more than halved, but the LCC will increase due to higher price for laptops. Note also that laptops have a shorter service life than desktops: 5.6 compared to 6.6 years. This means that the laptop cost will have to be paid more often, every 5.6 year instead of every 6.6 year.

Table 114 Impacts and costs per product for using laptops instead of desktops.

Base cases Life cycle impact/cost	Desktop office	Laptop office, adj	Desktop home	LCD at home	Desktop with LCD in home	Laptop home
Total Energy, GER (MJ)	16165	5663	12529	4473	17002	4995
Greenhouse Gases (kg CO2eq)	761	281	603	216	819	251
Product price (Euro)	620	1242	520	201	721	990
Electricity (Euro)	163	51	119	39	158	43
Repair & maintenance costs (Euro)	117	118	117	0	117	118
Total Euro	900	1411	756	240	996	1151

Since the BOM is changed, the figure below is included to show that also the other impact categories are decreased when using laptops instead of desktops in offices. Figure 11 shows that this is true for all impact categories. Since the greenhouse gas difference for this option is smaller in offices than in homes, the above statement will also hold true in homes.

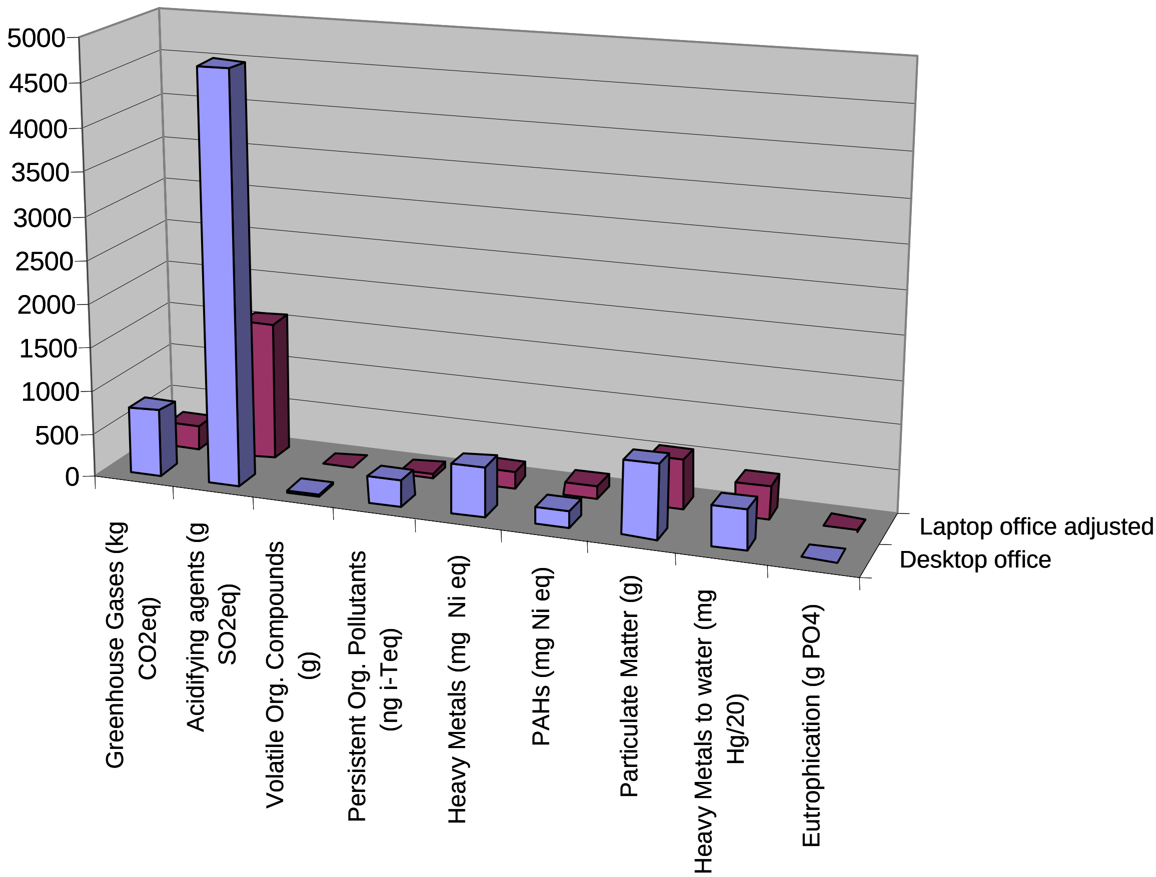

Figure 30 Environmental impacts when changing from desktop to laptop.

7.2.7 Change from LCD to LED backlight Screens

The table below gives total primary energy, total greenhouse gases and LCC per product for the improvement to use LED backlight screens instead of LCD screens. The environmental impact (and the electricity bill) can be reduced, but the LCC will increase due to higher price for LED screens.

Table 115

Base cases Life cycle impact/cost	Laptop office with LED	Laptop home with LED	LED Monitor office	LED Monitor-home
Total Energy, GER (MJ)	6831	4799	5824	3771
Greenhouse Gases (kg CO2eq)	331	243	275	186
Product price (Euro)	1292	1040	251	251
Electricity (Euro)	65	41	56	31
Repair & maintenance costs (Euro)	118	118	0	0
Total Euro	1475	1198	307	282

7.3 Analysis LLCC and BAT

7.3.1 Desktop office

The improvement options relevant for office desktops are listed in the Table below.

Table 116 Impacts and costs per product and improvement option (one by one) for office desktops.

Base cases Life cycle impact/cost	Base case	Power manage-ment	Dual core processor	Adaptive clock	80+ PSU	Replace ment laptop
Total Energy, GER (MJ)	16165	10166	13085	14080	13542	5663
Greenhouse Gases (kg CO2eq)	761	500	627	670	647	281
Product price (Euro)	620	620	630	620	625	1242
Electricity (Euro)	163	90	126	138	131	51
Repair & maintenance costs (Euro)	117	117	117	117	117	118
Total Euro	900	827	872	875	873	1411

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 117 Impacts and costs per product and improvement option added for office desktops.

	Base case	>80PSU	> 80PSU+ improved proc	> 80PSU+improved proc+adaptive intensity	Change to laptop	PM+> 80PSU+improve d proc+adaptive intensity
Total Energy, GER (MJ)	16165	13542	11173	9973	5663	7148
Greenhouse gases (kg CO2eq)	761	647	543	491	281	368
Product price (Euro)	620	625	635	635	1242	635
Electricity (Euro)	163	131	102	66	51	54
Repair and Maintenance costs (Eu	117	117	117	117	118	117
LCC (Euro)	900	873	854	840	1411	806

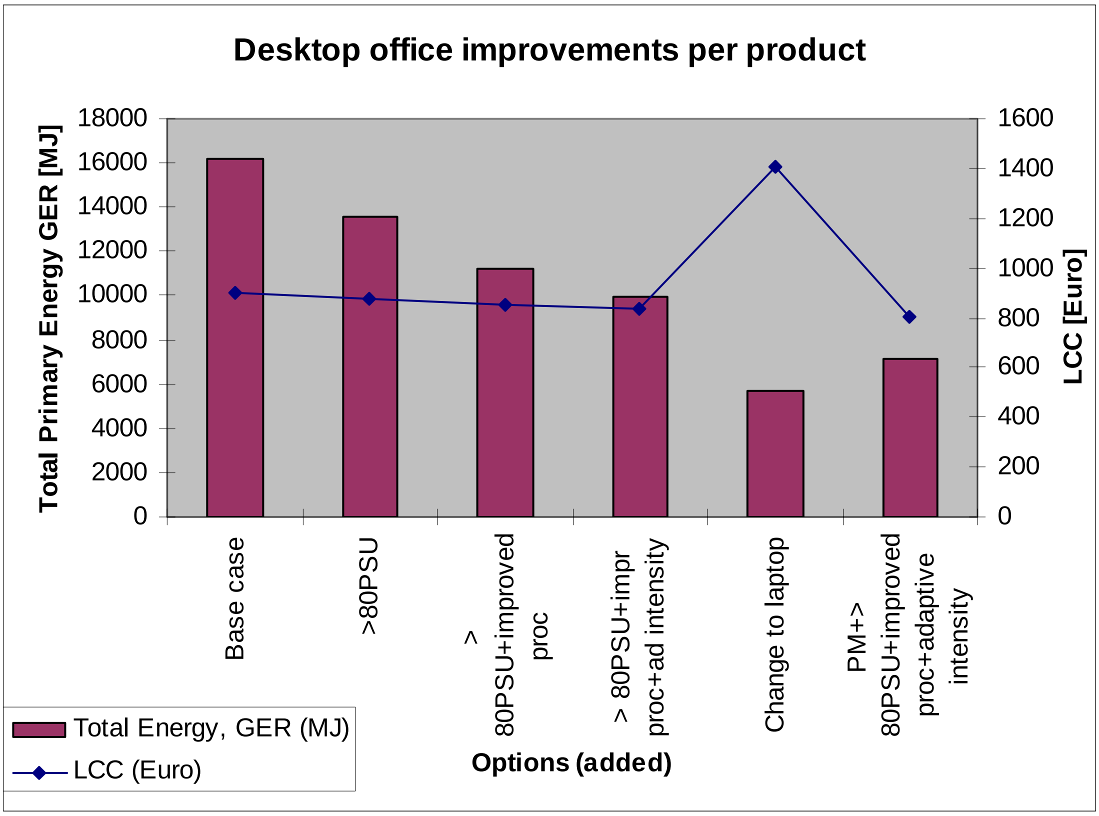

Figure 31 LCC and Total Primary Energy for Desktop office improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for desktop office products can be achieved by using “80-plus” Power supply unit, improved processor (such as dual core),adaptive processor intensity, and Power Management all at the same time. Total primary energy can be more than halved, while reducing the cost to the consumer by nearly 100 Euro.

7.3.2 Desktop home

The improvement options relevant for home desktops are listed in the Table below. They are identical (but not numerically) to the improvement options for office desktops with the exception of the replacement laptop, which should be compared to a desktop and a LCD-screen.

Table 118 Impacts and costs per product and improvement (one by one) for home desktops.

Base cases Life cycle impact/cost	**Base case**	**Power management**	**Dual core processor**	**Adaptive clock**	**80+ PSU**	**Desktop with LCD in home**	**Laptop home**
Total Energy, GER (MJ)	12529	8363	10392	11082	10610	17002	4995
Greenhouse gases (kg CO2eq)	603	421	509	540	519	819	251
Product price (Euro)	520	520	530	520	525	721	990
Electricity (Euro)	119	68	93	101	96	158	43
Repair & maintenance costs (Euro)	117	117	117	117	117	117	118
Total Euro	756	705	740	738	738	996	1151

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 119 Impacts and costs per product and improvement added for home desktops.

	Base case	>80 PSU	>80PSU+improved proc	>80PSU+improved proc+ad int	Change to laptop	PM+>80PSU+improved proc+adaptive intensity
Total Energy, GER (MJ)	12529	10610	8966	8133	4995	6269
Greenhouse gases (kg CO2eq)	603	519	447	411	251	329
Product price (Euro)	520	525	535	535	990	535
Electricity (Euro)	119	96	76	66	43	43
Repair and Maintenance costs (	117	117	117	117	118	117
LCC (Euro)	756	738	728	718	1151	695

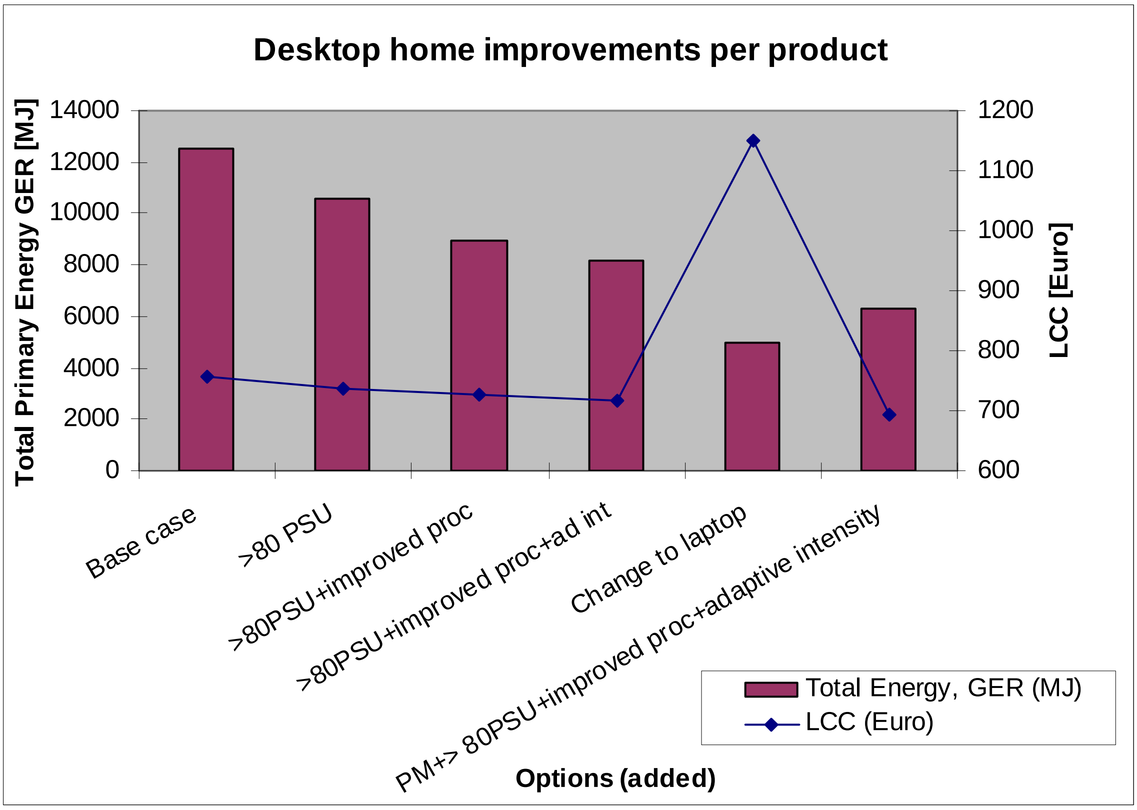

Figure 32 LCC and Total Primary Energy for Desktop home improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for desktop home products can be achieved by using “80-plus” Power supply unit, improved processor (such as dual core) and adaptive intensity processor and Power Management, all at the same time. Greenhouse gas emissions can be almost halved, while reducing the cost to the consumer by approximately 50 Euro.

7.3.3 Laptop office

The improvement options relevant for office laptops are listed in the Table below.

Table 120 Impacts and costs per product and option, one by one, for office laptops.

Base cases **Life cycle impact/cost**	**Base case**	**Power manage-ment**	**Dual core processor**	**80+ PSU**	**LED-screen**
Total Energy, GER (MJ)	7200	4973	6554	5895	6831
Greenhouse Gases (kg CO2eq)	348	250	319	291	331
Product price (Euro)	1242	1242	1257	1247	1292
Electricity (Euro)	70	43	62	54	65
Repair & maintenance costs (Euro)	118	118	118	118	118
Total Euro	1430	1403	1437	1419	1475

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 121 Impacts and costs per product and improvement added for office laptops.

	Base case	>80PSU	> 80PSU+ improved proc	> 80PSU+improved proc+LED	PM+>80PSU
Total Energy, GER (MJ)	7200	5895	5428	5157	4481
Greenhouse gases (kg CO2eq)	348	291	270	258	229
Product price (Euro)	1242	1247	1262	1312	1247
Electricity (Euro)	70	54	48	45	37
Repair and Maintenance costs (Euro)	118	118	118	118	118
LCC (Euro)	1430	1419	1428	1475	1402

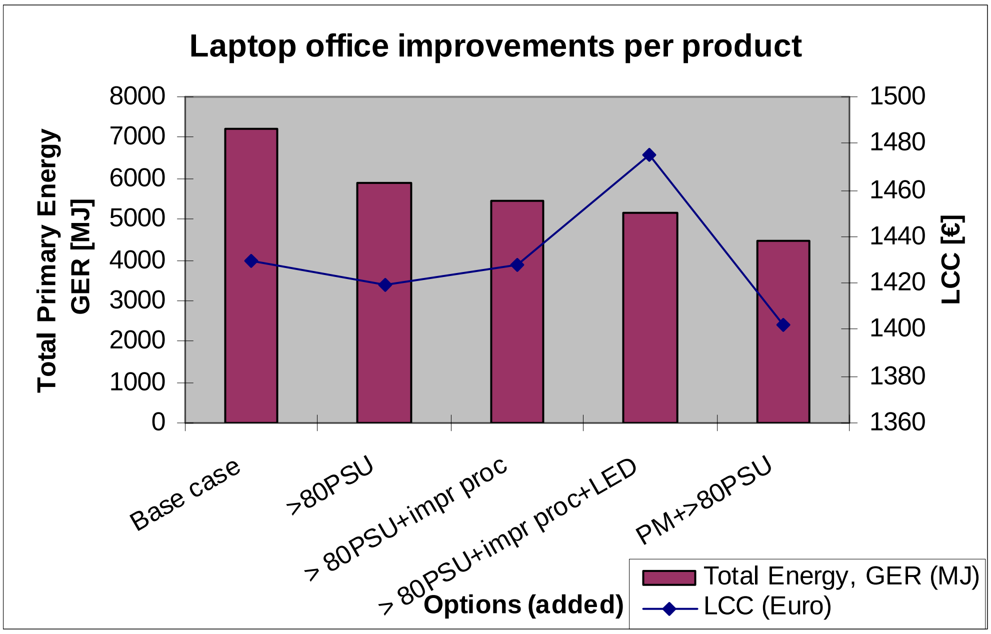

Figure 33 LCC and Total Primary Energy for Laptop office improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for laptop office products can be achieved by using "80-plus" Power supply unit and Power Management at the same time. Total primary energy would then be reduced by 35%, while reducing the cost to the consumer by approximately 30 Euro.

7.3.4 Laptop home

The improvement options relevant for home laptops are listed in the Table below.

Table 122 Impacts and costs per product and improvement one by one, for home laptops

Base cases Life cycle impact/cost	Base case	Power manage-ment	Dual core processor	80+ PSU	LED-screen
Total Energy, GER (MJ)	4995	3811	4701	4119	4799
Greenhouse Gases (kg CO2eq)	251	200	239	213	243
Product price (Euro)	990	990	1005	995	1040
Electricity (Euro)	43	29	39	32	41
Repair & maintenance costs (Euro)	118	118	118	118	118
Total Euro	1151	1136	1162	1145	1198

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 123 Impacts and costs per product and improvement added for home laptops.

	Base case	>80PSU	>80PSU+improved proc	>80PSU+improved proc+LED	PM+>80PSU
Total Energy, GER (MJ)	4995	4119	3866	3727	3550
Greenhouse gases (kg CO2eq)	251	213	202	196	188
Product price (Euro)	990	995	1010	1060	995
Electricity (Euro)	43	32	29	27	25
Repair and Maintenance costs (Euro)	118	118	118	118	118
LCC (Euro)	1151	1145	1157	1205	1138

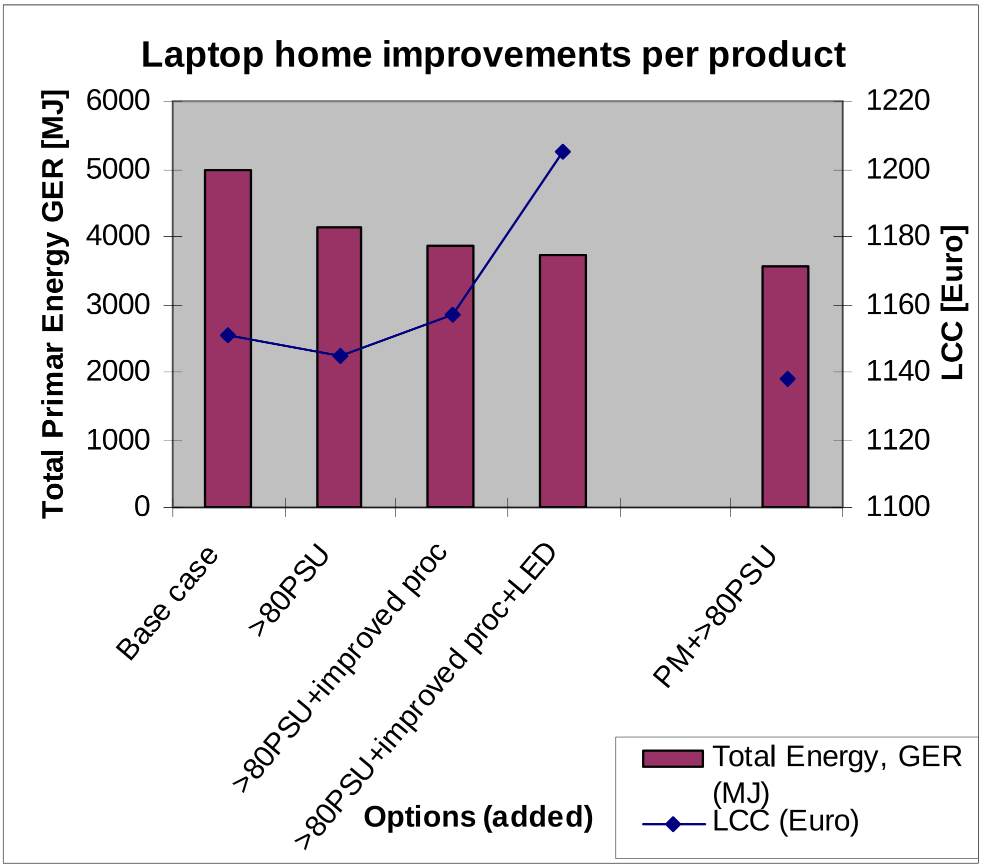

Figure 34 LCC and Total Primary Energy for Laptop home improvements, added.

Conclusion from this is that LLCC (least life cycle cost) for laptop home products can be achieved by using 80-plus power supply and Power Management at the same time.

7.3.5 LCD in office

The improvement options relevant for LCD-screens in offices are listed in the Table below.

Table 124 Impacts and costs per product and option one by one for LCD-screens in offices.

Base cases **Life cycle impact/cost**	**Base case**	**Power manage-ment**	**80+ PSU**	**LED instead of LCD**
Total Energy, GER (MJ)	7231	4498	6102	5824
Greenhouse Gases (kg CO2eq)	336	217	287	275
Product price (Euro)	201	201	206	251
Electricity (Euro)	73	40	59	56
Repair & maintenance costs (Euro)	0	0	0	0
Total Euro	274	241	265	307

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the largest impact on LCC first.

Table 125 Impacts and costs per product and improvement added for office LCD.

	Base case	>80PSU	>80PSU+LED	PM+>80PSU
Total Energy, GER (MJ)	7231	6102	4973	3934
Greenhouse gases (kg CO2eq)	336	287	238	193
Product price (Euro)	201	206	256	206
Electricity (Euro)	73	59	45	33
Repair and Maintenance costs (Euro)	0	0	0	0
LCC (Euro)	274	265	301	239

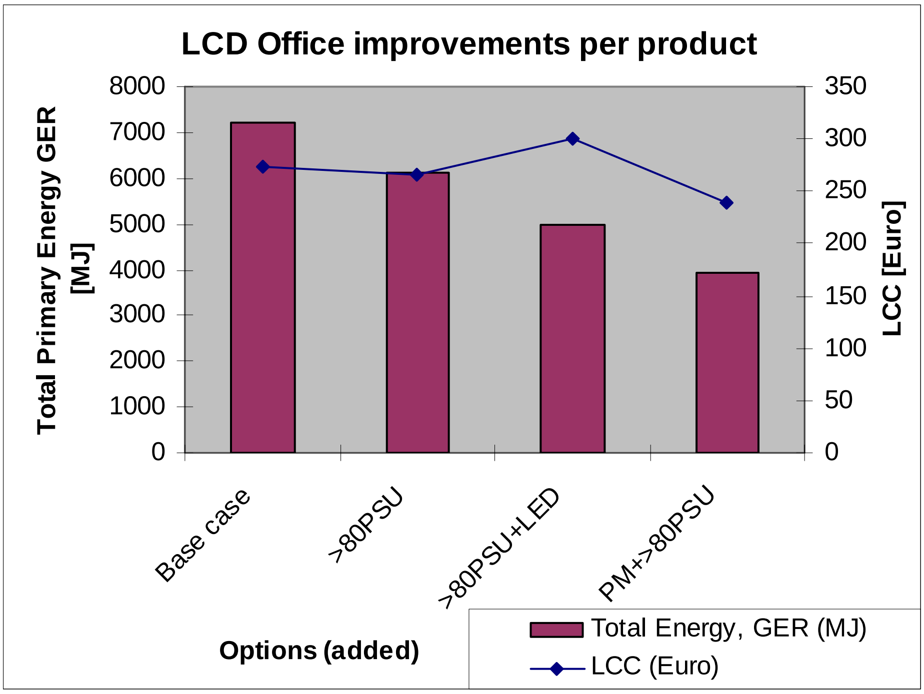

Figure 35 LCC and Total Primary Energy for LCD office improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for LCD office products can be achieved by using Power Management and "80-plus" Power supply unit at the same time. Total primary energy can be reduced by 45%, while reducing the cost to the consumer by approximately 70 Euro.

7.3.6 LCD in home

The improvement options relevant for LCD-screens in homes are listed in the Table below.

Table 126 Impacts and costs perproduct and option one by one for LCD-screens in homes.

Base cases Life cycle impact/cost	Base case	Power manage-ment	80+ PSU	LED instead of LCD
Total Energy, GER (MJ)	4473	3112	3910	3771
Greenhouse Gases (kg CO2eq)	216	157	192	186
Product price (Euro)	201	201	206	251
Electricity (Euro)	39	23	32	31
Repair & maintenance costs (Euro)	0	0	0	0
Total Euro	240	224	238	282

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 127 Impacts and costs per product and improvement added for home LCD

	Base case	>80PSU	>80PSU+LED	PM+>80PSU
Total Energy, GER (MJ)	4473	3910	3349	2830
Greenhouse gases (kg CO2eq)	216	192	167	144
Product price (Euro)	201	206	256	206
Electricity (Euro)	39	32	26	19
Repair and Maintenance costs (Euro)	0	0	0	0
LCC (Euro)	240	238	282	225

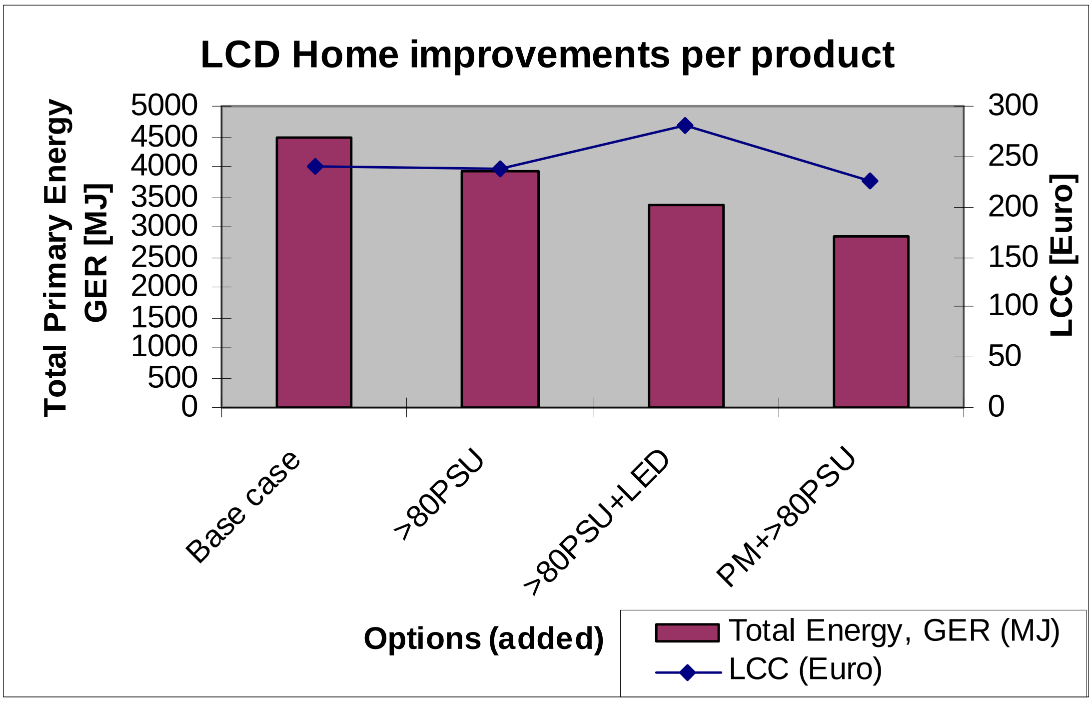

Figure 36 LCC and Total primary energy for LCD home improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for LCD home products can be achieved by using 80-plus power supply and Power Management at the same time.

7.3.7 CRT in office

The improvement options relevant for CRT-screens in offices are listed in the Table below.

Table 128 Impacts and costs per product and improvement one by one for CRT-screens in offices.

Base cases **Life cycle impact/cost**	**Base case**	**Power manage-ment**	**80+ PSU**	**LCD-screen**
Total Energy, GER (MJ)	14515	8422	11942	7231
Greenhouse Gases (kg CO2eq)	657	391	545	336
Product price (Euro)	73	73	78	201
Electricity (Euro)	159	85	127	73
Repair & maintenance costs (Euro)	0	0	0	0
Total Euro	232	158	205	274

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the largest impact on LCC first.

Table 129 Impacts and costs per product and improvement added for office CRT.

	Base case	>80PSU	PM+>80PSU	LCD-screen
Total Energy, GER (MJ)	14515	11942	7177	7231
Greenhouse gases (kg CO2eq)	657	545	337	336
Product price (Euro)	73	78	78	201
Electricity (Euro)	159	127	70	73
Repair and Maintenance costs (Euro)	0	0		
LCC (Euro)	232	205	148	274

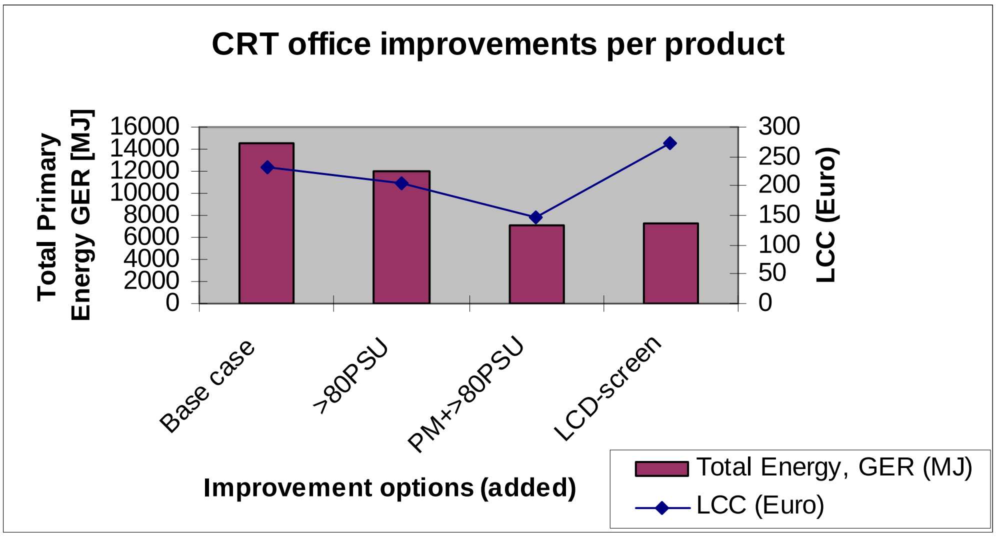

Figure 37 LCC and Total primary energy for CRT office improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for CRT office products can be achieved by using Power Management and “80-plus” Power supply unit at the same time. Total primary energy can be halved, while reducing the cost to the consumer by almost 100 Euro.

7.3.8 CRT in home

The improvement options relevant for CRT-screens in homes are listed in the Table below.

Table 130 Impacts and costs per product and option (one by one) for CRT-screens in homes.

Base cases Life cycle impact/cost	Base case	Power manage-ment	80+ PSU	LCD-screen
Total Energy, GER (MJ)	8403	5369	6994	4473
Greenhouse Gases (kg CO2eq)	390	258	329	216
Product price (Euro)	73	73	78	201
Electricity (Euro)	85	48	68	39
Repair & maintenance costs (Euro)	0	0	0	0
Total Euro	158	121	146	240

In order to find out the impact and LCC if more than one improvement option is used, combinations of the options have been calculated with the Ecoreport tool. The calculation order of the options is chosen to give the hardware options first.

Table 131 Impacts and costs per product and option added for CRT-screens in homes.

	Base case	>80PSU	PM+>80 PSU	Change to LCD
Total Energy, GER (MJ)	8403	6994	4747	4473
Greenhouse gases (kg CO2eq)	390	329	231	216
Product price (Euro)	73	78	78	201
Electricity (Euro)	85	68	40	39
Repair and Maintenance costs (Euro)	0	0	0	0
LCC (Euro)	158	146	118	240

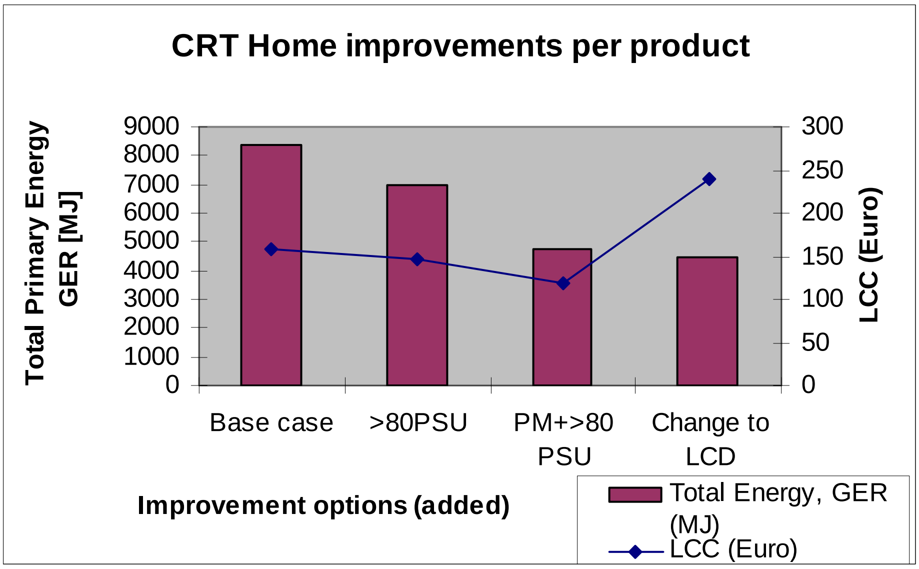

Figure 38 LCC and Greenhouse gases for CRT home improvements, added.

From the above figure it can be concluded that LLCC (least life cycle cost) for LCD home products can be achieved by using Power Management and a “80-plus” power supply unit at the same time. Total primary energy can be reduced by 40%, while reducing the cost to the consumer by 40 Euro.

7.3.9 Conclusions

For all the products evaluated, it is obvious that power management has a very high potential for improvement. It is of even more value if the future behavior of the users of the products, due to broadband connections and other features, induces that people leaves the products on all the time. Highly efficient power supply units do also have a high potential for improvement, even if the LCC increases slightly for products that are used less frequently. For most products and usage patterns, the highly efficient power supply units decrease the LCC. For desktops, it is obvious that highly efficient processors, such as dual core, and processors with adaptive clock frequency have a high potential for improvement. The reason why that is not the case for laptops, is that for these products that improvement is already implemented.

7.3.10 Impact of improvements on EU totals

Below it is shown what it would mean to total emissions in EU-25, if all the options with LLCC, as described above in 7.3.1-7.3.8, would have been implemented on the installed base 2005.

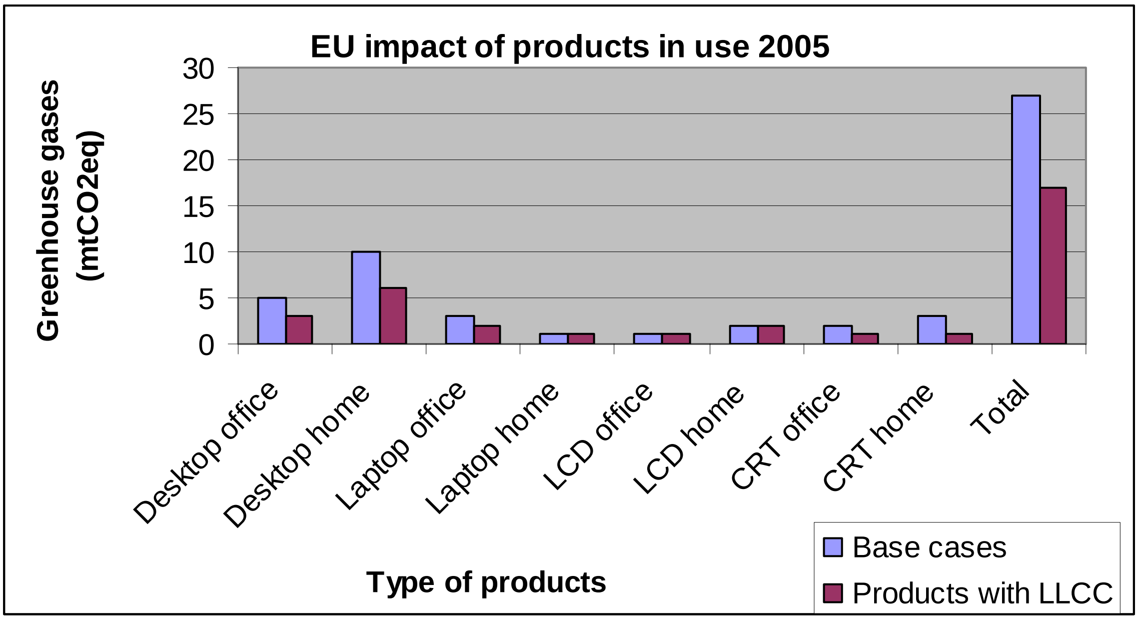

Figure 39 EU Impact of Products in 2005 (produced, in use, discarded) Greenhouse gases (mtCO2eq) for base case products and LLCC products.

A conclusion from this is that there is a lot of greenhouse gases to save, approximately 10 mega tones ($10*10^9$ kg) CO2-eq, if all the products in use 2005 were changed to the ones with the least life cycle cost LLCC.

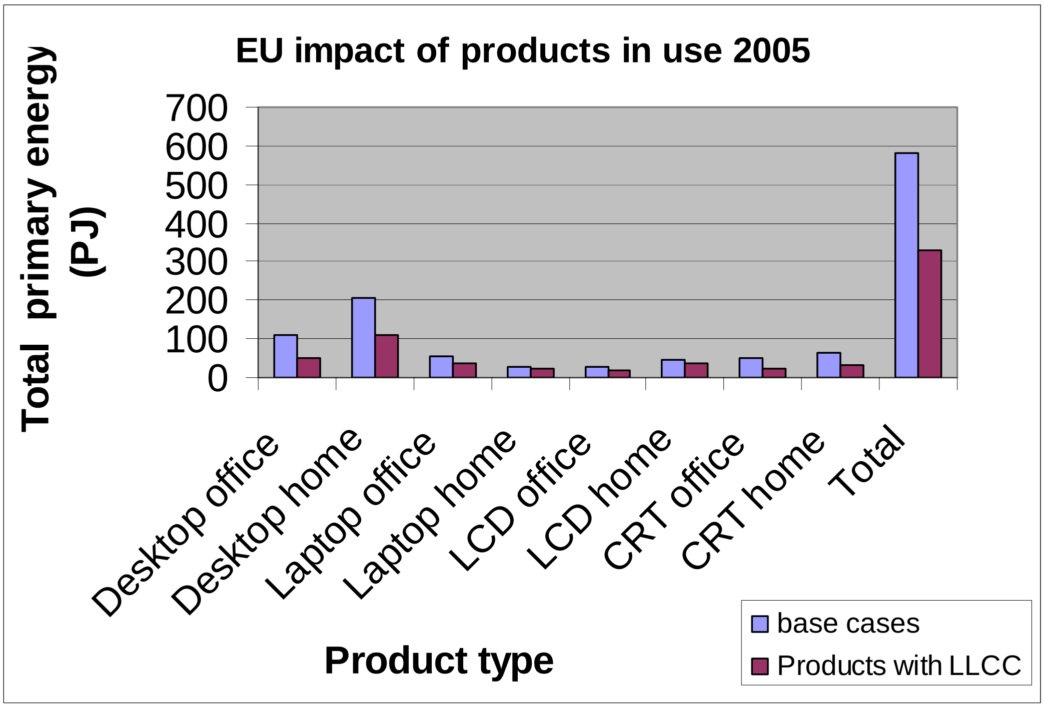

Figure 40 EU Impact of Products in use 2005 (produced, in use, discarded), total primary energy for base case products and LLCC products.

Figure 21 shows that the potential to save primary energy if all products in use 2005 were changed to the ones with least life cycle cost, would be approximately 255 PJ (255 $*10^{15}$ Joule).

7.4 Long-term targets (BNAT) and systems analysis

7.4.1 Thin Clients

A thin client is a PC without a hard drive. It contains an operating system in RAM but relies on a server for other software applications. The normal configuration is that the server supports a number of thin clients that can run the applications on that server. The intended uses for these types of PCs are normal office applications. There are several benefits of using a thin client. The energy consumption of the thin client is low, the start up time is short since the operating system is in RAM, and since the software applications are located on a server the maintenance of the software is simple. The major draw back of the thin client is that it cannot be used as a stand alone PC. It relies on the network connection to the server to function as intended.
Due to the low energy consumption there has been an increased interest in this type of PCs for office use the last years. The thin client is, however, not a part of this EuP study.

7.4.2 Influence from Software

The performance of software is not within the real scope of this study, but since the effects on the LCC of computer products are quite significant it is still worth to comment.

The potential positive influence from power management, have been covered in several of the previous chapters, but it is also obvious that the full potentials of the hardware power management functions, very seldom are utilized due to software problems or even perceived software problems.

The recently introduced operating system Vista include much more powerful power management functionality than the previous operating systems, but due to the increased demands for computer capacity for other functions, the improvements from Vista in environmental aspects is questionable.

The increased capacity and functionality from new software is obvious, more graphics, easier to use, better integration of different applications and so on. But seen from another standpoint, the relation, real improvements in capacity versus increased demands for computing power are not that positive. The documents written in a brand new word-processor are not that much better than the documents written a couple of years ago using much less computing power and energy, neither are the spread-sheets.

The potential for better LCC from dedicated software development with energy efficiency in focus is quite high, but it has probably not yet become a strong enough selling argument, to influence the new products.

7.4.3 Consumer behavior

The consumer behavior has a great impact on the environmental performance of products evaluated in this study. One option with high improvement potential not calculated here could therefore be consumer information. The information would help the users to understand and use power management in a proper way, and could also offer guidance in purchasing choices. Information can be delivered in many ways; such as implementing easy access tutorial tools integrated in the computer software or at a website. Another solution might be to educate all pupils at school, to provide them with a “driving license for computers”. The impact of such educations could be huge. Today information given from the manufacturers and/or suppliers of computers is not good enough to help most people to use power management in a proper way.

7.5 References

- Battery chargers and external power supplies. Final report. Lot 7. January 23 2007
- Computer Memorandum of Understanding (Version 3.0) between The United States Environmental Protection Agency
- Energy Star® Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1)
- Energy Star® Program Requirements for Computers: Final Draft Version 4.0
- MEEUP Methodology Report. Final Report. Methodology Study Ecodesign of Energy-using Products. 28.11.2005. VHK for European Commission. Available at http://www.vhk.nl/
- Deep interviews with computer, monitor and component manufacturers under non-disclosure agreements to get information about best available technologies, improvements and their improvement potential. The number of companies interviewed was 10 and the number of persons 27.

8 Scenario-, Policy-, Impact- and Sensitivity analysis

Background

In the previous tasks of this study, definitions, existing legislation and voluntary agreements have been studied. Market volumes, trade flows and projections for the future have been investigated, and accepted by the stakeholders. Base cases for relevant computers and monitors have been calculated for desktops, laptops, CRT monitors and LCD monitors. Improvement options and their improvement potential have been identified for all of the base cases, taking indicated use patterns into account. For each base case and improvement option a life cycle assessment on the basis of the MEEuP has been done.

8.1 Policy- and scenario analysis

In this chapter the intention is to show scenarios improving the environmental performance and energy consumption from computers and monitors. The task is quite complicated, especially due to the very fast advances both in technology and possible changes of usage for computers. The scenarios are to be stretched as far as 2020, thus giving quite a lot of causes for uncertainties, both due to technology and to market development.

According to previous tasks, the main environmental impact is the energy used during use. Energy use is depending on power and time, therefore different options to reduce either power in different modes or to reduce time in high power modes are considered. Currently no benchmarking method for assessing a computer's energy efficiency is available. Idle-on is currently used as an indicator for on-mode consumption. However, minimum requirements on idle-on could be problematic since the impact of future technology development, in particular software, cannot be assessed reliably. An alternative strategy for computers is to focus on “unnecessary waste” when the computer power is not needed and inefficiencies in power conversion. In order to take into account on-mode power, a scenario consisting of ecodesign requirements for low power modes complemented with Energy Star voluntary labelling based on modified values (compared to tier I coming into force on 20 July) for idle-on is considered. On the other hand, for computer monitors on-mode is considered in a scenario relating on-mode power consumption to the resolution (the approach currently implemented in Energy Star), and/or the to the screen size.

8.1.1 Estimated market data

To be able to calculate the impact from the different options as far in the future as 2020, an estimation of the installed base of computers must be done up to that date. Due to the high uncertainties of the computer market and computer usage at such a distant time, an assumption has been made based on extrapolation of the trends identified up to 2010. Economic lifetimes are considered to be the same for the whole period. Arguments can be found for both longer and shorter lifetimes.

The apparent consumption has been estimated in task 2, and is displayed for convenience again in the following graph.

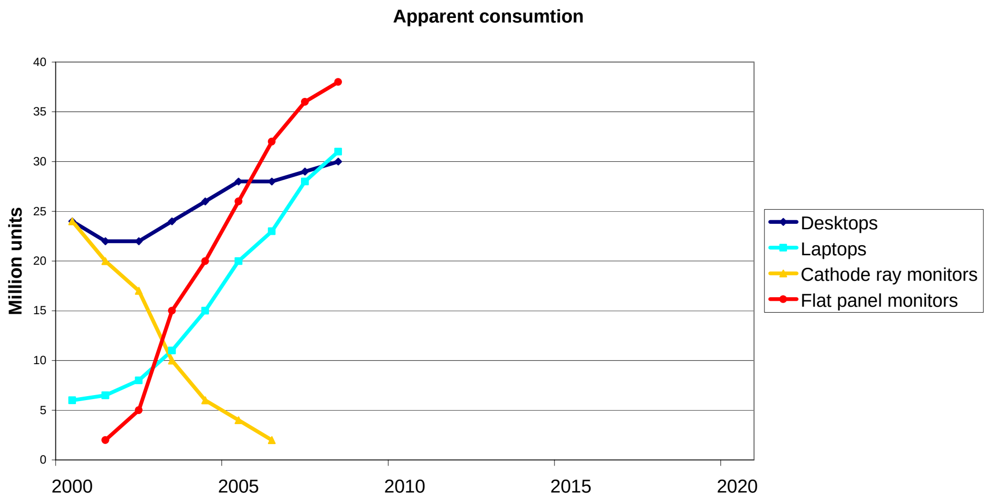

Figure 41   Apparent consumption from Task 2.

Due to the uncertainties of the input data and the uncertainties of technology, the apparent consumption from 2010 up to 2020 has been estimated by manual extrapolation. See the graph below.

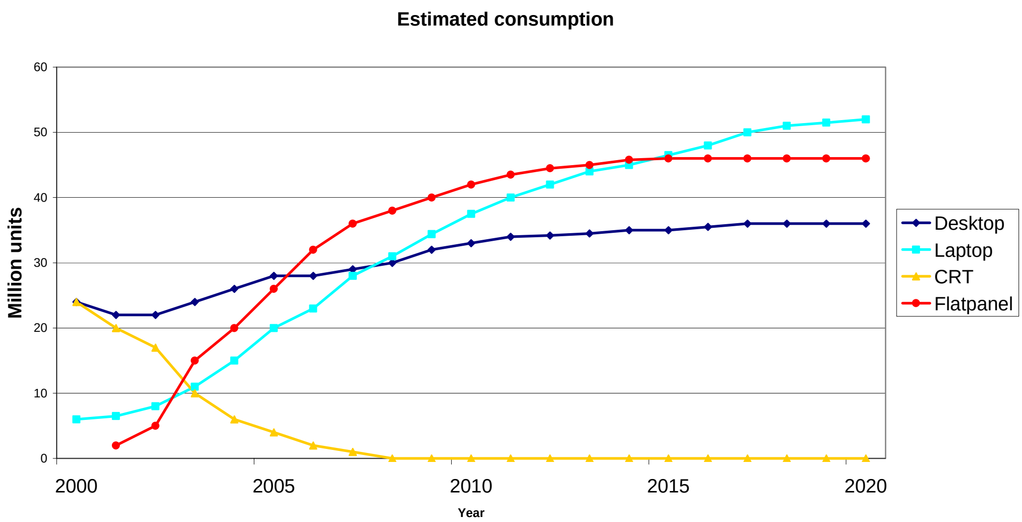

Figure 42   Estimated consumption to 2020.

Integrating the consumption over the estimated lifetimes, 5 years for Laptops and 6 years for the rest, gives the installed base. See the graph below.

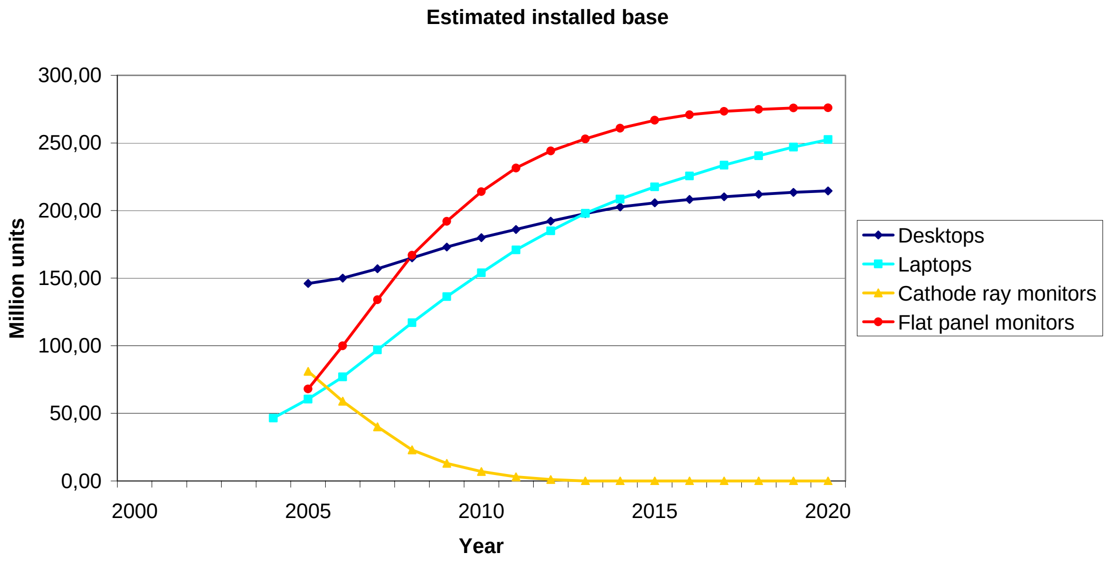

Figure 43 Estimated installed base.

In the table below the figures are given in digital form.

Table 132 Estimated installed base

	Desktops (millions)	Laptops (millions)	Cathode ray monitors (millions)	Flat panel monitors (millions)
2000				
2001				
2002				
2003				
2004		46,50		
2005	146,00	60,50	81,00	68,00
2006	150,00	77,00	59,00	100,00
2007	157,00	97,00	40,00	134,00
2008	165,00	117,00	23,00	167,00
2009	173,00	136,40	13,00	192,00
2010	180,00	153,90	7,00	214,00
2011	186,00	170,90	3,00	231,50
2012	192,20	184,90	1,00	244,00
2013	197,70	197,90	0,00	253,00
2014	202,70	208,50	0,00	260,80
2015	205,70	217,50	0,00	266,80
2016	208,20	225,50	0,00	270,80
2017	210,20	233,50	0,00	273,30
2018	212,00	240,50	0,00	274,80
2019	213,50	247,00	0,00	275,80
2020	214,50	252,50	0,00	276,00

8.1.2 Overview of scenarios described

In order to get an overview of the scenarios described in the subsequent text, a table of the scenarios, and their main features is included.

Table 133 A comparison between scenarios described by the study
Note; details, about the different options, such as figures for limits, is further described at each scenario.

Scenario	**High efficient PSU**	**Power management enabled**	**Information about power levels**	**Idle/active level**	**Sleep/off levels**
1. Business as usual I	Voluntary in E* tier I for computers	Voluntary in E* tier I for computers and monitors	-	Voluntary in E* tier I for computers and tier II monitors	Voluntary in E* for computers and monitors
2 Business as usual II, including Energy Star tier II for computers as foreseen for 2009 in Energy Star Agreement	Voluntary in E* (same as tier I) for computers	Voluntary in E* (same as tier I) for computers and monitors	-	Voluntary in E* first tier I then tier II Assumption of tier II, implemented 2009 is to decrease the tier I limits by 10% on idle-on mode for the different categories of computers.	Voluntary in E* for computers and monitors
3. Possible option A for implementing measures **(base is business as usual I)**	Mandatory from 2009 for desktops, laptops and monitors	Mandatory from 2009 for computers (including power down of monitors)	-	Mandatory minimum requirements for monitors from 2009 (power/resolution) Mandatory minimum requirements for power/area for monitors from 2011 Mandatory minimum requirements for idle for computers in line with E* tier I from 2010	Mandatory minimum requirements for computers and monitors from 2009
4. Possible option B for implementing measures **(base is business as usual I)**	Mandatory from 2009 for desktops and monitors	Mandatory for computers (including power down of monitors) from 2009	Mandatory from 2009	Mandatory minimum requirements for monitors from 2009 (power/resolution) Mandatory minimum requirements for power/area for monitors from 2011	Mandatory minimum requirements on all products from 2009

Scenario	High efficient PSU	Power management enabled	Information about power levels	Idle/active level	Sleep/off levels
5. Industry recommendation	Computers: Mandatory efficiency of 75% for desktops, 84% for notebooks from 2009 and 80% for desktops, from 2011	Computers (including power down of monitors) Mandatory from 2009	-	Voluntary in E* Monitors: Mandatory levels for monitors from 2009 (power/resolution)	Voluntary in E* Mandatory from 2009 for all products Mandatory from 2011 with harder limits for Computers

8.1.3 Scenario 1, Business as usual I

To describe the improvement potential of each implementing measure, and to make a comparison, a business as usual scenario is established.

The business as usual scenario is based on the estimated installed base described above, on environmental performance of products available on the market 2005 and with the Energy Star 4.0 in place 2007 (for criteria, see task 1). Our assumption is that 10% of the new computers 2007 will fulfil the Energy Star 4.0 criteria, and that this rate will increase by 10% each year until 65% of new products fulfil the criteria in 2011, leading to that 65% of all computers in use fulfil the Energy Star 4.0 criteria in 2015. Note that old products already in use will not be affected causing this considerable delay. The increase in primary energy use is very much depending on the increase in the installed base of products.

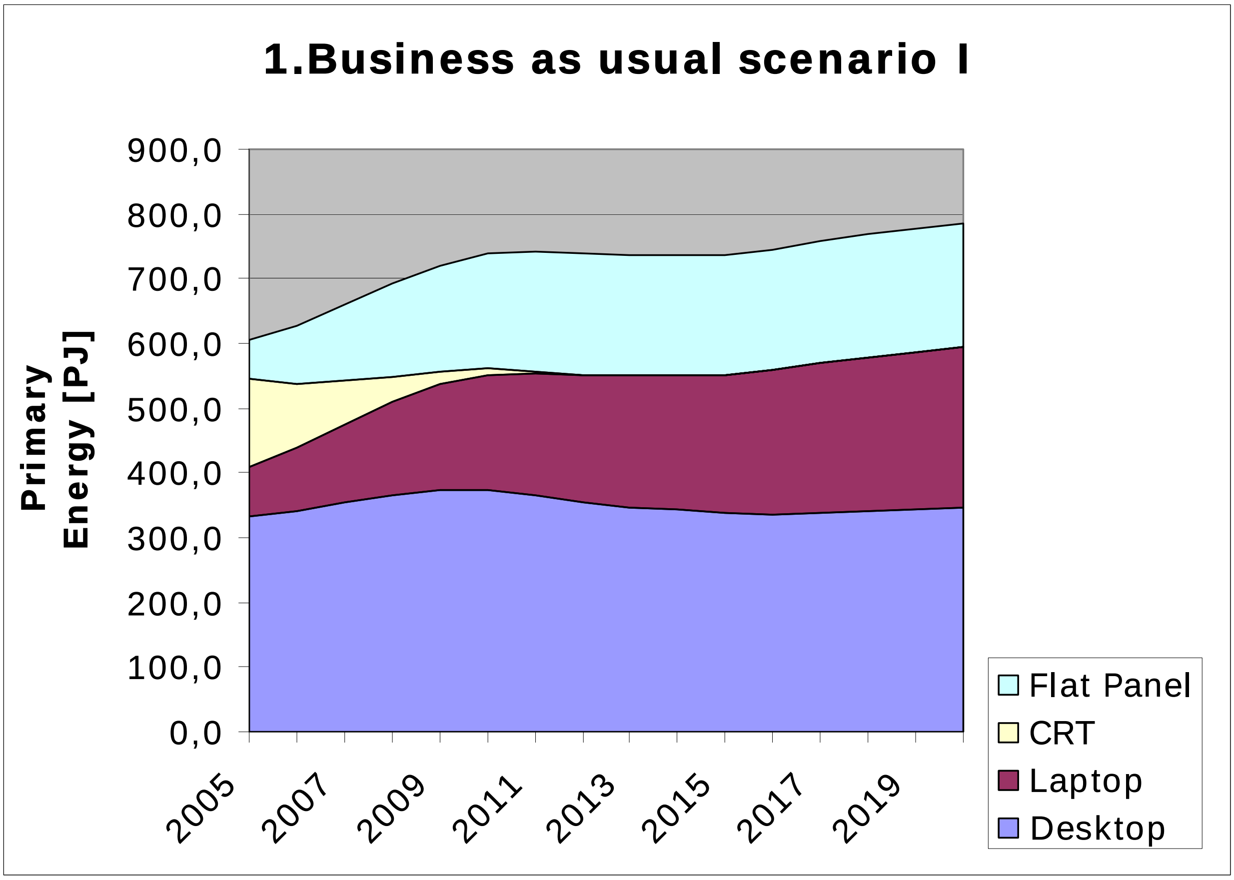

Figure 44 Primary Energy use in a Business as usual I scenario.

Table 134 Primary Energy use in a Business as usual I scenario

	1. Business as usual I					
	Desktop	Laptop	CRT	Flat Panel	Monitors	Summa
2005	331,4	76,4	138,2	60,1	198,3	606,2
2006	340,5	97,3	100,7	88,3	189,0	626,8
2007	353,8	121,7	67,8	117,7	185,5	661,0
2008	364,9	144,3	38,4	144,6	183,0	692,1
2009	372,4	164,1	21,2	163,0	184,2	720,6
2010	372,3	178,5	11,0	176,4	187,4	738,2
2011	364,4	188,6	4,5	183,4	187,9	740,9
2012	355,5	195,3	1,4	185,5	186,9	737,7
2013	347,4	202,2	0,0	185,5	185,5	735,1
2014	342,6	207,6	0,0	186,1	186,1	736,2
2015	337,2	213,8	0,0	186,4	186,4	737,4
2016	336,1	221,6	0,0	187,2	187,2	744,9
2017	339,3	229,5	0,0	188,9	188,9	757,7
2018	342,2	236,4	0,0	190,0	190,0	768,6
2019	344,7	242,8	0,0	190,6	190,6	778,1
2020	346,3	248,2	0,0	190,8	190,8	785,2

8.1.4 Scenario 2, Business as usual II

The business as usual II scenario is similar to the business as usual I scenario, but with Energy Star, tier II with more demanding criteria for idle-mode power for computers in place from 2010. Currently it is unclear how new Energy Star monitor specs will look like, therefore no "updated" BaU for monitors possible. The criteria are assumed to decrease the idle mode power by 10% for each of the categories defined for desktops and laptops, based on the share of new products from each category, compared with the average idle power found in this study (task 4). Based on the impact of on-mode (for products already provided with power management and efficient power supply units), it is assumed to cause a decrease of use energy by 7,1% for desktop office, 6,1% for desktop home, 6,2 % for laptop office and 4,7% for laptop home compared to tier I.

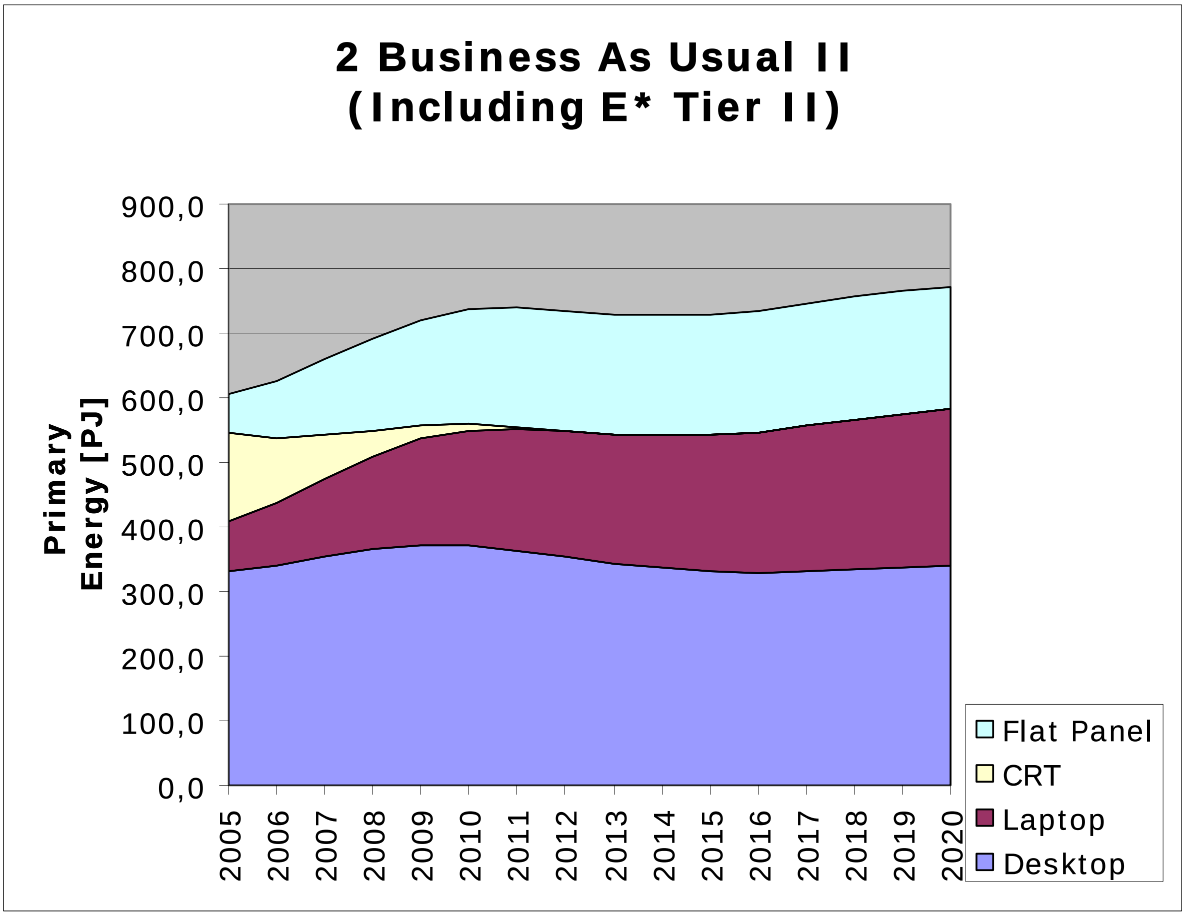

Figure 45 Primary Energy use in a Business as usual II scenario

Table 135   Primary Energy use in a Business as usual II scenario.

	2 Business as usual II (Including E* Tier II)					
	Desktop	Laptop	CRT	Flat Panel	Monitors	Summa
2005	331,4	76,4	138,2	60,1	198,3	606,2
2006	340,5	97,3	100,7	88,3	189,0	626,8
2007	353,8	121,7	67,8	117,7	185,5	661,0
2008	364,9	144,3	38,4	144,6	183,0	692,1
2009	372,2	164,0	21,2	163,0	184,2	720,4
2010	371,7	178,2	11,0	176,4	187,4	737,3
2011	363,2	187,9	4,5	183,4	187,9	739,0
2012	353,5	193,9	1,4	185,5	186,9	734,3
2013	344,1	199,9	0,0	185,5	185,5	729,5
2014	338,0	204,4	0,0	186,1	186,1	728,5
2015	331,7	209,9	0,0	186,4	186,4	727,9
2016	329,7	217,2	0,0	187,2	187,2	734,0
2017	332,3	224,6	0,0	188,9	188,9	745,9
2018	334,9	231,4	0,0	190,0	190,0	756,2
2019	337,2	237,6	0,0	190,6	190,6	765,5
2020	338,8	242,9	0,0	190,8	190,8	772,5

8.1.5 Implementing measures in general

Implementing measures can take different forms: Legislation on minimum requirements for power consumption or technical solutions, which will be elaborated later, or measures such as requirements for information on power use in different use modes. Other options include voluntary schemes, like the current Energy Star or the TCO labelling for monitors.

Minimum requirements for power consumption are quite powerful and will have an effect on all new computers. However, there could be a risk that the requirements will become obsolete quickly due to rapid technological development. It can be difficult to make such requirements specific enough to provide desired effects, while at the same time avoiding to lock in old technology solutions.

Requirements related to provision of information of for example power consumption in different modes is another option. Such an approach fosters market transparency, and may lead to efforts from industry to improve power consumption

Several voluntary labels exist and are used regarding the products in this study. Energy Star and TCO labelling schemes are for example often used in public procurement. However, voluntary labels may lead to that some low cost producers avoid the labelling system. These could be the producers with less energy efficient products.

8.1.6 Scenario 3. Possible option A for implementing measures

According to previous tasks, the main environmental impact is the energy used during use. Energy use is depending on power and time, therefore the implementing measures are focused on minimising the power in different modes and minimising the time in high power modes.

Mandatory minimum requirements for power modes for Computers

This scenario off/standby and sleep power mandatory requirements is harmonised with Energy Star 4.0, Tier 1, for PCs. These values also correspond to the Lot 6 findings, although the definitions of modes are different.

Table 136 Comparison/correlation of definitions between Lot 6 (stand-by and off mode) and Lot 3 (personal computer and computer monitors)

Lot 6 definitions	**Lot 3 definitions**
Off-mode	Off mode (without Wake On Lan, WOL)
Passive standby	Off-mode (including WOL)
Networked standby, type II (standard rate networks)	Sleep

Sleep (S3)

- 4W/4.7 W (for desktops), the higher values corresponding to allowances for wake on LAN
- 1.7W/2.4 W (for laptops).

Off/standby

- 2W/2.7 W (for desktops)
- 1W/1.7 W (for notebooks).

Although the base cases in this study use lower values for sleep and off, these minimum requirements will have an impact on products exceeding the base case values, e.g. from the "white box" sector. It will also have an impact when the increased use of power management transforms idle use into sleep or off/standby, and thereby make the sleep or off/standby power more important. There is also a trend to go for very powerful computers in some niches, where this limits for sleep and standby/off can have a large impact without jeopardizing the product performance.

Idle-on mode

Currently no benchmarking method for assessing a computer's energy efficiency is available. Idle-on is currently used as an indicator for on-mode consumption. A possible option could be to make minimum requirements in line with Energy Star criteria, tier 1 for idle mode power. That would mean the following levels:

- Desktop (categories definition in task 1.3)
  - Category A: $\leq$ 50.0 W
  - Category B: $\leq$ 65.0 W
  - Category C: $\leq$ 95.0 W
- Notebooks (with screen shut off)
  - Category A: $\leq$ 14.0 W
  - Category B: $\leq$ 22.0 W

This suggestion is assumed to decrease the energy use during use when applied to products that have already implemented efficient power supply and mandatory power management enabled. Some high-end products, such as gaming computers, will have difficulties in fulfilling the requirement. Adding an extra category for this kind of products could solve this. In addition, the LCC could increase with 30-100€ according to industry information e.g. due to the cost of for improved energy efficient graphic cards in order to fulfil the needs from Vista and the optional mandatory requirements at the same time. This requirement could thereby become not in line with Least Life Cycle Cost approach.

A possibly even better option could be to wait for the benchmarking tool, now developed by the industry (ECMA). If that succeeds, it will make it possible to develop requirements related to the performance of computers, so that implementing measures will surely lead to improved energy-efficiency at minimum cost. Industry and Energy Star have great confidence in the success of this endeavour.

Mandatory minimum requirements for power modes for Monitors

Active/on mode

The power consumption for a computer monitor in on-mode is related to the screen size (see background document on Monitors (to be included in task 4-5 in the final report)). Energy Star Program Requirements for Computer Monitors version 4.1 uses power per resolution as a base for the requirements. The equation Y=38*X+30 is used, where Y is the threshold limit for active/on power in Watt and X is the number of mega pixels in decimal form. With reference to task 4, the Lot 3 study recommends to develop a requirement related to the area of the screen. Based on the data available, an indicative recommendation is to place the threshold limit at Y= 10+410*A, where Y is the active/on power in Watts and A is a “true” value in m^2 for the area of the screen surface. Almost all the products from the Energy Star database - products that fulfil the Energy Star Tier 2 criteria according to the Energy Star measurement method – is below the indicative Y= 10+410*A level.

The recommendation was also compared with tests made by the German Magazine Computertechnik during the years 1998 to 2006 including almost 300 monitors. The measurement standard for Computertechnik’s tests is unknown but assumed consistent. In the figure below the almost 300 LCD screens tested in Germany are plotted together with 500 LCD screens that fulfil the criteria of E* 4.1 Tier 2. As can be seen, some monitors would not comply with the threshold limit Y= 10+410*A, hence there is some potential for energy savings. The estimated improvement is a 5% decrease of energy during use.

Since Energy Star is a well-known and widely used system, the Lot 3 recommendation is to start with the industry proposal of power per resolution as a first step of implementing measures. The limits recommended by industry and in accordance with Energy Star are suitable to start with, i.e. Max power Y=38*X+30, where Y is the active/on power in Watt and X is the number of mega pixels in decimal form. The requirement is only recommended for monitors < 30”. This first step is recommended to be adopted as soon as possible (assumed to be equal to 2009).

As a second step, Lot 3 recommends to develop requirements for power per area, which will have a wider impact. Furthermore, Lot 3 recommends developing the Energy Star system so that also the future Energy Star criteria for monitors are based on power per area, but at lower values than the mandatory minimum requirements at that time. (Possibly at the level of Y=5+410*A). Preferably minimum requirements and the voluntary Energy Star use the same base. The timing of this requirement is suggested to around 2011, in order to allow for adequate adaptation to the new scheme. At that time, it is also estimated that CRTs, which could have problems in fulfilling the requirements, will not have any market share of importance.

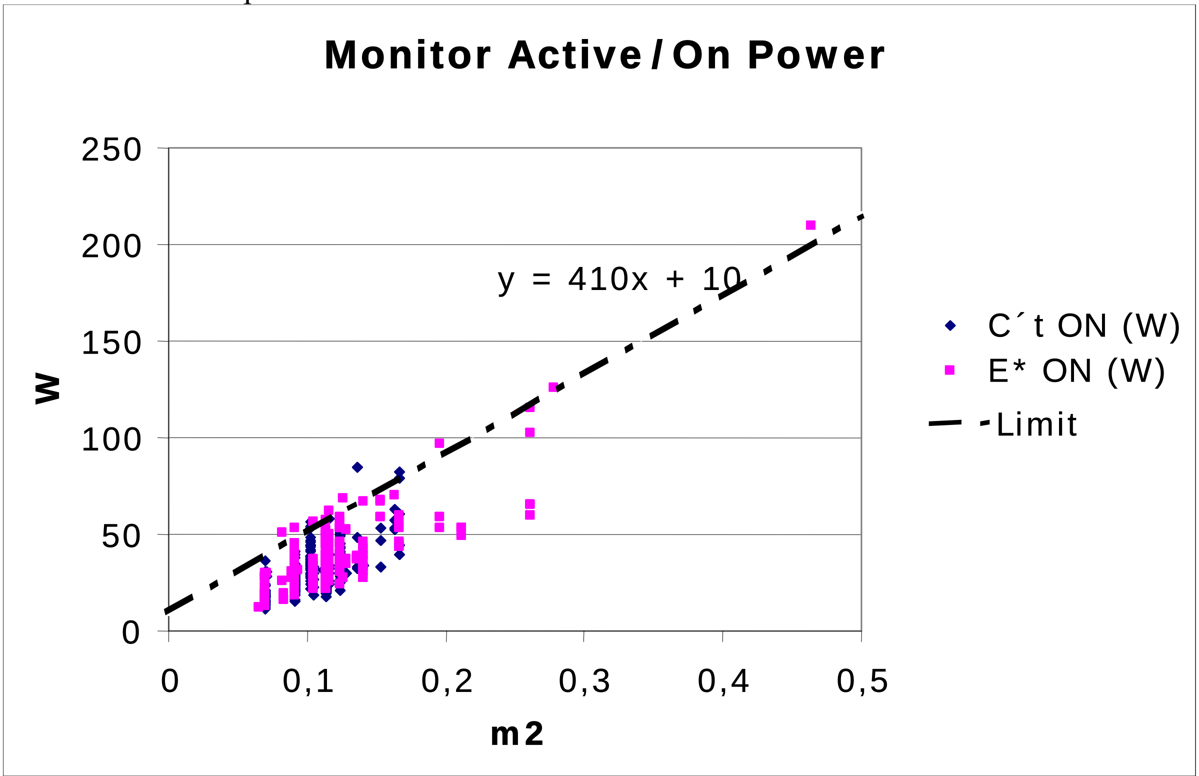

Figure 46 Suggestion for Active/on mode power for Monitors, compared to statistics available from E (Energy Star database) and C´t (Computertechnik)*

This recommendation is based on the Energy Star measurement method, but where the power is related to area and not to resolution. The Energy Star measurement method for monitors today is quite good, but can be further developed by letting the test engineer use a luminance meter and measure the difference between the grey levels, instead of the perceptual evaluation used today. The standard could for example state that the levels are considered to be different if the luminance differ more than 5 cd/m^2 between two levels. In this way the repeatability of the test method would be improved.

Sleep and off mode

In this scenario sleep and off mode power for monitors follow Energy Star, tier 2, i.e. sleep mode $\leq$2W and off mode $\leq$1W. Viewed in the context of also requiring enabled energy management, this recommendation will also effect the power consumption presently allocated to the active/on mode. In task 7 is estimated that improved power management could result in around 40% reduction of the total power consumption.

Mandatory requirements for Power supply unit efficiency

Power supplies for desktops and laptops and for monitors in today's market, show a relatively large distribution in efficiency. It is obvious that technology is available to get efficiency in the area of 80-85% and even higher, while some units on the market have considerably less efficiency. Due to the work done in Energy Star, there is an accepted definition for efficiency, taking into account the wide variation of power consumption in the different operational modes for a computer.

Lot 3 recommends the following efficiency requirements (following the Energy Star test methods and criteria for internal power supplies and Lot 7 findings for external power supplies.)

- For Internal power supply (desktops and monitors): 80% minimum efficiency at 20%, 50%, 80% and 100% of rated output and Power Factor ≥ 0.9 of rated output
- For external power supply (laptops): 85% minimum efficiency.

The measurement methods available at Energy Star do not include internal power supplies for monitors. Such a measurement method therefore needs to be developed. This has to be done, but it should be very much the same as the one currently applied method for computers.

Suggested timing

The main difference between the Lot 3 recommendation and the recommendation made by industry is that Lot 3 includes power supply units for monitors, and the timing. The time for industry to change to more efficient power supply units depends on the availability of components, of which the industry is restrained. Since the technology is already established, it can be assumed that the availability of components will not become the limiting factor, but that the time for legislation (Consultation forum and other processes) is the limiting factor. Therefore the implementation should be as soon as possible (we assume 2009). Many persons in industry have confirmed this assumption in informal discussions.

As a second step it could also be recommended to make an even higher efficiency of power supply units, such as +85% or +90%, a mandatory requirement. This would give quite a large impact on energy use, but the measure has to be further developed.

Mandatory enabling of Power management at system level

One of the most effective measures for energy conservation in computers would be to enforce the use of power management at system or software level. Most modern computer hardware has a very advanced, built in, functionality for power management, which is often not used. Many users even actively turn off the power management function due to anticipated problems with legacy software and with network applications. The solution for a successful use of power management is almost exclusively a software (operating system) issue, but the computer manufacturers can do the enabling of the power management. Lot 3 recommends mandatory enabling of power management before shipping the product.

Some studies made by the industry (and shared with the Lot 3 under NDA) show that for products with an enabled power management system, less than 20% of the users turn it off, leading to a much higher use of such a system than if the user have to actively enable it. Estimated impact of the mandatory enabled power management, is therefore based on that 80% of the products use power management when enabled power management is mandatory.

The Lot 3 recommendation is to introduce legislation which forces the manufacturers to provide the computers with the power management system **enabled** at the time of delivery to the customers. Information about how to use the power management system should also be provided in such a way that it is easy for ordinary people to understand. (Today's information is often hidden deep in the software or the manual, and rather difficult to understand.)

Suggested settings for the power management is (according to Energy Star 4.0 and the proposal from EICTA, AeA, and JBCE):

- 15 min to screen off (display sleep)
- 30 min to computer sleep (System Level S3, suspended to RAM).

Timing

Since power management systems are available and usually installed already, the only change would, in most cases, be to enable them, and make the description better, leading to a possibility for implementation as soon as possible.

Energy Star and other voluntary labelling schemes

Energy Star is a well-established labelling system, described in task 1, based on voluntary agreements. The business as usual comparison scenario is essentially the effects expected from Energy Star as it is today, but the requirements in Energy Star will also be developed, thus improving the effects from voluntary labelling.

Energy Star has the necessary infrastructure for maintenance of the demands for being allowed to use the label. The Energy Star system include:

- Power supply unit efficiency
- Power consumption levels
- Power management at system level
- Requirements on information.

The Energy Star labelling scheme criteria is based on the performance of approx the 25% best of the available products on the market when the criteria are set. The criteria are updated, following a time plan, and for computers, the Energy Star version 4, tier 2 criteria will be effective from January 1 2009. There is a work ongoing in the ECMA group, to develop a computer performance-benchmarking test, in order to make the criteria on energy consumption depend on the computer performance. If successfully developed, the ECMA performance measure should be used in the mandatory information suggested above, giving the energy per performance, (similar to the energy per area for computer monitors).

Furthermore, Lot 3 recommends as described above, developing the Energy Star system so that also the future Energy Star criteria for monitors are based on power per area, but at lower values than the mandatory minimum requirements at that time. (Possibly at the level of Y=5+410*A for E*, where Y is the active power in W and A is the screen area in m^2 of the monitor) Energy Star complements the implementing measures recommended by Lot 3. The combination of measures can further enhance the environmental performance of the products studied. There are also other voluntary labelling schemes, such as TCO, the EU-flower, the Swan and the Blue Angel. They have criteria for many other environmental aspects including material content and recycling, thus complementing Energy Star and the implementing measures recommended by Lot 3, by putting attention on other issues than energy.

Impact of scenario 3, Possible option A for implementing measures

The main assumptions for the calculations in scenario 3, Possible option A for implementing measures are:

- Energy Star requirements is implemented as assumed in Business as usual scenario I
- Power management at the described settings is assumed to become mandatory enabled 2009
- High efficient power supply units for desktops, laptops and monitors becomes mandatory 2009
- Minimum requirements for sleep and off becomes mandatory 2009
- Minimum requirements for idle mode for computers becomes mandatory 2010 in line with Energy Star criteria, tier 1. It is assumed that all new products will comply with these requirements from 2010, leading to the full stock compliant in 2016
- Minimum requirements for power per resolution for monitors is estimated to become mandatory in 2009
- The requirement for active/on-mode power per area for monitors is estimated to become mandatory 2011 and complemented with the new developed Energy Star criteria for monitor active on-mode power. It is estimated to decrease the average power in active mode for monitors by

5%.

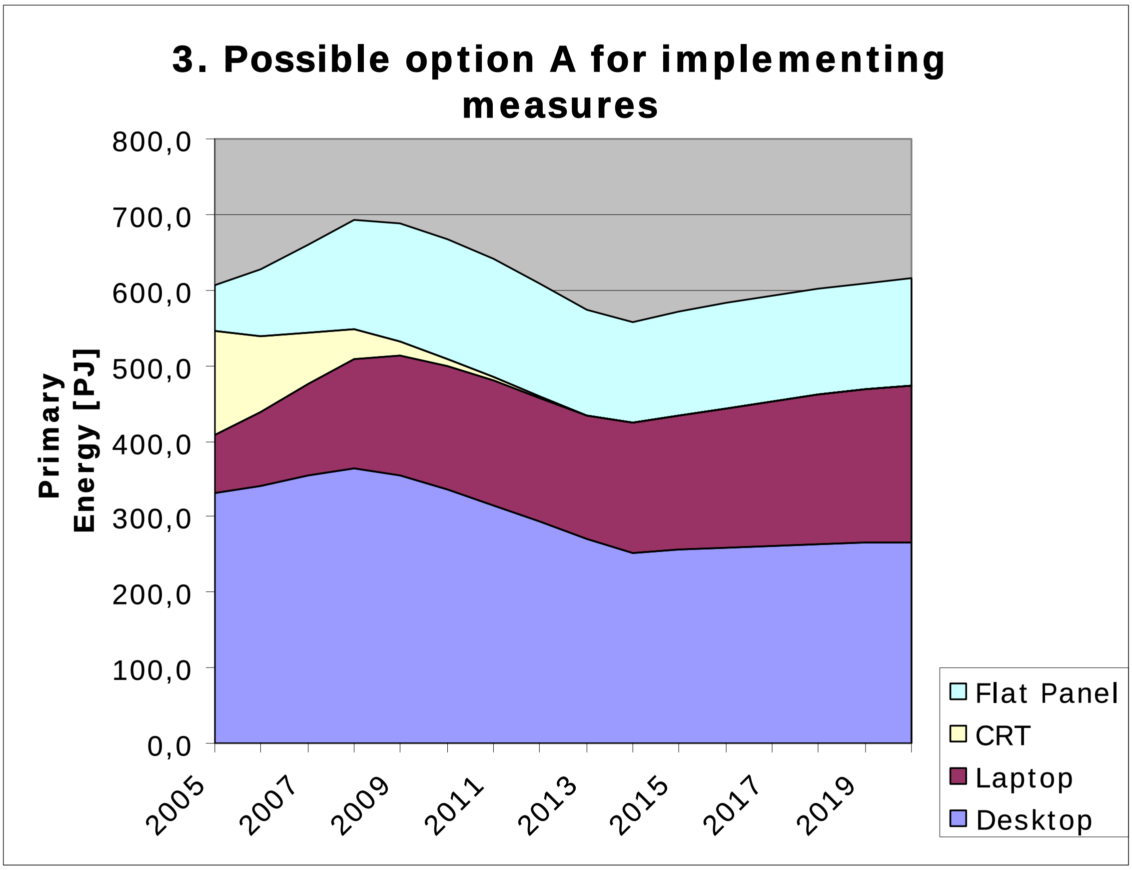

Figure 47 Primary energy use for the Possible option A for implementing measures scenario (including idle requirements for computers from 2010)

Table 137 Primary energy use for the Possible option A for implementing measures scenario (including idle requirements for computers from 2010).

	3. Possible option A for implementing measures (incl idle limits)					
	Desktop	Laptop	CRT	Flat Panel	Monitors	Summa
2005	331,4	76,4	138,2	60,1	198,3	606,2
2006	340,5	97,3	100,7	88,3	189,0	626,8
2007	353,8	121,7	67,8	117,7	185,5	661,0
2008	364,9	144,3	38,4	144,6	183,0	692,1
2009	353,5	159,1	20,4	154,2	174,5	687,1
2010	336,3	162,4	10,2	159,1	169,4	668,1
2011	315,7	165,2	4,1	156,3	160,4	641,3
2012	293,4	164,0	1,2	149,6	150,8	608,2
2013	271,4	162,4	0,0	141,0	141,0	574,7
2014	252,3	171,1	0,0	133,2	133,2	556,5
2015	256,0	178,5	0,0	136,2	136,2	570,7
2016	259,1	185,0	0,0	138,3	138,3	582,4
2017	261,6	191,6	0,0	139,5	139,5	592,7
2018	263,9	197,3	0,0	140,3	140,3	601,5
2019	265,7	202,7	0,0	140,8	140,8	609,2
2020	267,0	207,2	0,0	140,9	140,9	615,1

This shows a large impact on the primary energy used compared to Business as usual scenarios. Approximately half of the improvement is due to implemented power management, and secondly comes the implemented high efficient power supplies (one third of the improvement).

8.1.7 Scenario 4. Possible option B for implementing measures

According to previous tasks, the main environmental impact is the energy used during use. Energy use is depending on power and time; therefore the implementing measures are focused on minimising the power in different modes and minimising the time in high power modes. Currently no benchmarking method for assessing a computer's energy efficiency is available. Idle-on is currently used as an indicator for on-mode consumption. However, as mentioned above, minimum requirements on idle-on could be problematic. We suggest the following alternative scenario without minimum requirements for idle power for computer. Information requirements are included in this scenario in order to support energy efficient products. For computer monitors on-mode is considered in a scenario relating on-mode power consumption to the resolution (the approach currently implemented in Energy Star), and/or the to the screen size.

The implementing measures are based on the Least Life Cycle Cost, LLCC, described in task 7. This means that no measures that would give a higher cost for the consumer are considered.

This scenario is very similar to scenario 3, why only the implementing measures changed compared to that scenario is described.

Information requirement

This scenario includes (with a view to article 14 in 2005/32/EC), a requirement to inform the consumer about personal computers' and monitors' power consumption in the relevant modes: idle or active, sleep and off", according to Energy Star measurement methods. Such measures enhance market transparency.

Lot 3 recommends that it should be required to present the information at the outer surface of the product, possibly on a sticker, and in the product manual in a highly visible place. It is of importance that the information is on the outside of the product (not in the software or inside the casing), so it can be seen when already on the shelf in the store, and also when the equipment is shipped to end of life treatment. The ECMA standard 370, Eco Declaration, include most of the information suggested by Lot 3 (and a lot of more detailed information). The main difference is that it is an additional document, not a sticker on the product or information included in the manual.

Lot 3 recommends that it should be required to inform the consumer about personal computers and monitors' content of restricted substances such as mercury and lead. Since the presence of these substances is of importance in the end-of-life treatment, it is vital that the information is placed visibly on the outer surface of the product.

Information to be given for personal computers (desktops and laptops), according to measurement methods, described in Energy Star Program Requirements for Computers (version 4.0) is

- Power use in idle mode (or power per performance when the ECMA benchmarking tool is available)
- Power use in sleep mode
- Power use in off mode
- Content of restricted substances such as mercury (e.g. in the lamps)
- Web page address for information on Energy, Environment and End of life treatment.

Information to be given for computer monitors, according to measurement methods, described in Energy Star program Requirements for Computer Monitors (Version 4.1).

- Power use in active mode per product and per area (m2)
- Power use in sleep mode per product
- Power use in off mode per product
- Content of restricted substances such as mercury and lead
- Web page address for information on Energy, Environment and End of life treatment

Web page

The Lot 3 study recommends the establishment of a neutral web page, run by the EU, or a third party, whereto all the manufacturers have to report information about certain issues. What to report is:

- Power consumption in different modes (described above)
- Instructions (or a link to instructions) for the customer on what to do when it is time for End of life treatment. Information for all the countries where the product is sold
- Information about the power management system available in the product.

The consumers shall be able to use the web page to make comparisons on energy related issues between all available products. The information should be provided in a way that makes it easy for ordinary people to understand. The website could also provide a simple tool, similar to the calculation tool available at the Energy Star web page, where people can calculate their own energy cost. That can be done from input of their own use (hours a week in idle/sleep and off), power data of the products they are looking at, and their own energy price. Connected to this tool, instructions on how to use power management (i.e time settings and how to wake up from sleep), and the consequences of that shall be described. Perhaps by default values in the tool.

Suggested timing

Since this suggestion only calls for the industry to make measurements according to established measuring methods and develop the information, we suggest this requirement to be introduced as soon as possible it is assumed that this legislation will force the manufacturers to use the better performing processors, called processor power management (power management at component level).

A mandatory information sticker is assumed to affect all new products. In the graph below the requirement is assumed to be introduced in 2009. And the full impact is reached after 5-6 years (phasing out old products).

Impact of scenario 4. Possible option B for implementing measures

The main assumptions for the calculations for scenario 4, Possible option B for implementing measures are:

- Energy Star requirements is implemented as assumed in Business as usual scenario I
- Power management at the described settings is assumed to become mandatory enabled 2009
- High efficient power supply units for desktops, laptops and monitors becomes mandatory 2009

- Minimum requirements for sleep and off becomes mandatory 2009
- Information requirements will support the use of power management at component level (making the processors more efficient) and become mandatory 2009
- Minimum requirements for power per resolution for monitors is estimated to become mandatory in 2009
- The recommended minimum requirement for active/on-mode power for monitors is estimated to become mandatory 2011 and complemented with the new developed Energy Star criteria for monitor active on-mode power. It is estimated to decrease the average power in active mode for monitors by 5%
- No minimum requirements for idle-mode for computers is included
- The Least Life Cycle Cost calculations made in task 7 supports all the recommended implementing measures.

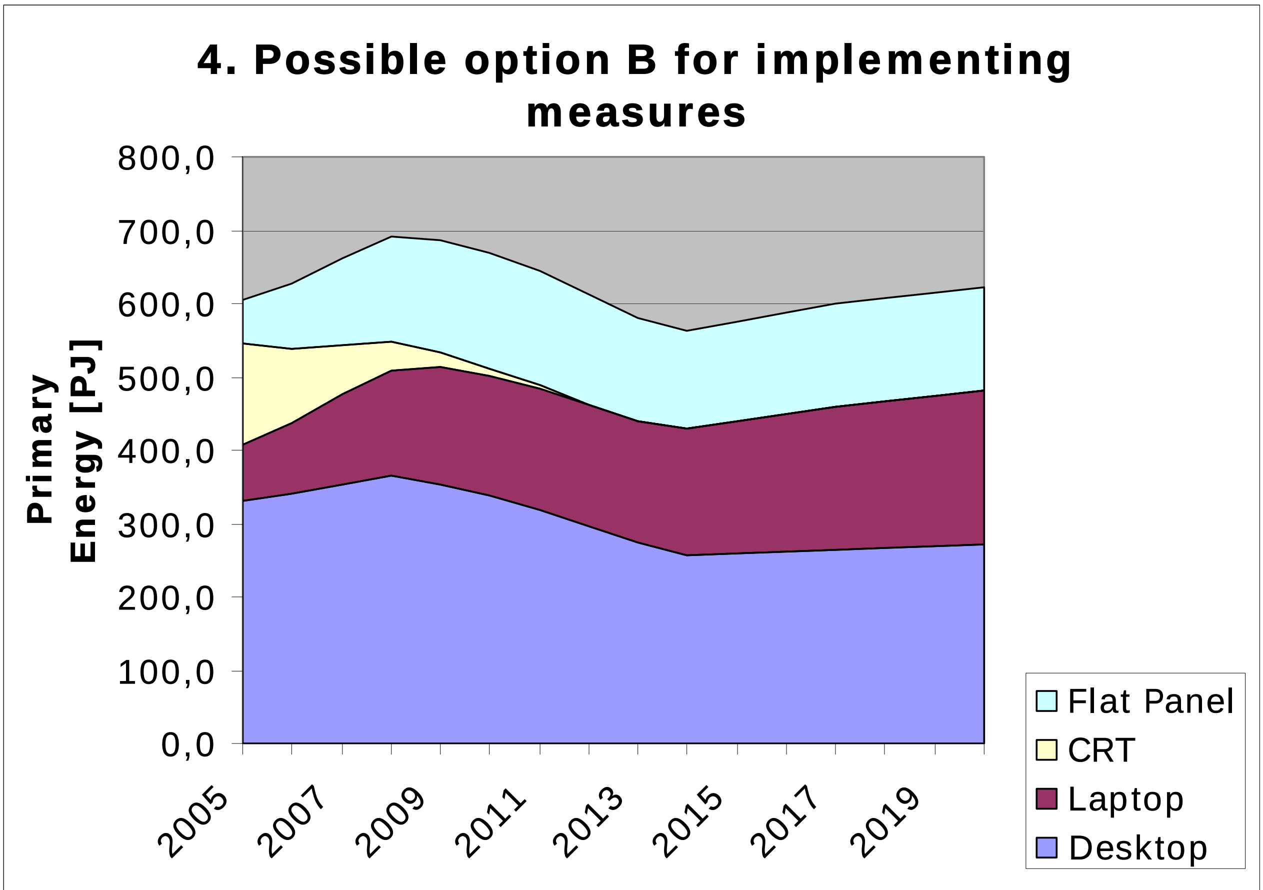

Figure 48 Primary energy use in scenario 4. Possible option B for implementing measures

Table 138 Primary energy use in scenario 4. Possible option B for implementing measures.

	4. Possible option B for implementing measures					
	Desktop	Laptop	CRT	Flat Panel	Monitors	Summa
2005	331,4	76,4	138,2	60,1	198,3	606,2
2006	340,5	97,3	100,7	88,3	189,0	626,8
2007	353,8	121,7	67,8	117,7	185,5	661,0
2008	364,9	144,3	38,4	144,6	183,0	692,1
2009	353,5	159,1	20,4	154,2	174,5	687,1
2010	337,5	163,2	10,2	159,1	169,4	670,1
2011	317,5	166,5	4,1	156,3	160,4	644,3
2012	295,7	165,8	1,2	149,6	150,8	612,3
2013	274,3	164,6	0,0	141,0	141,0	579,8
2014	255,6	173,4	0,0	133,2	133,2	562,2
2015	259,4	180,9	0,0	136,2	136,2	576,5
2016	262,6	187,5	0,0	138,3	138,3	588,4
2017	265,1	194,2	0,0	139,5	139,5	598,8
2018	267,4	200,0	0,0	140,3	140,3	607,7
2019	269,3	205,4	0,0	140,8	140,8	615,5
2020	270,5	210,0	0,0	140,9	140,9	621,4

This shows a large impact on the primary energy used compared to Business as usual scenarios. Approximately half of the improvement is due to implemented power management, and secondly comes the implemented high efficient power supplies (one third of the improvement).

8.1.8 Scenario 5. Industry recommendation

EICTA, AeA, and JBCE have submitted a suggestion for Ecodesign Requirements Options, which is included as an appendix to this report (EICTA, AeA, and JBCE 2007). The main issues are given in the following figure.

Feature	Product Category	Ecodesign requirements options (allowing for one product re-design cycle)	Ecodesign requirement options with prolonged transition time (e.g. 4+ years out)	Test procedure
Internal Power Supplier/IPS	Desktops	• 70% efficient at 20% load • 75% efficient at 50% and full load	• 80% efficiency levels (tested at 20%, 50%, and 100% loading)s • 0.9PF (Power Factor) at 100% load	http://www.efficientpowersupplies.org/
External Power Supplies (EPS)	Desktops, Notebooks	Must correspond with recommended improvement options for EuP Lot 7: • ≥84% efficiency (tested at 100%, 75%, 50%, and 25% of rated current output) • No load: 0.75 W (Harmonized with California CEC, E* Tier II for EPS)	n.a.	http://www.energystar.gov/ia/partners/prod_development/downloads/power_supplies/EPSupplyEffic_TestMethod_0804.pdf
Sleep	Desktops, Notebooks	Sleep (S3): • 10 W • Shipped w/ power management enabled • Computers enter low-power state after 30 minutes of inactivity	Sleep (S3): • 4 W/ 4.7 W (for desktops) • 1 W/ 1.7 W (for notebooks) (Harmonized with E* 4.0 Tier 1 for PCs)	http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Computer_Spec_Final.pdf
Off / Standby	Desktops, Notebooks	Off/standby (S4/S5): • 5 W	Off/standby (S4/S5): • 2 W / 2.7 W (for desktops) • 1.7 W / 2.4 W (for notebooks) (Harmonized with E* 4.0 Tier 1 for PCs)	http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Computer_Spec_Final.pdf
Display Energy	Displays (only LCD smaller 30")	• Maximum active power consumption equation: Y = 38X + 30. (Y is expressed in watts and rounded up to the nearest whole number and X is the number of mega pixels in decimal form) • Sleep Mode ≤ 4 W • Off Mode ≤ 2 W • Shipped w/ power management enabled • Displays enter sleep mode after 15 minutes of inactivity (Harmonized with E* 4.1 Tier 1 (covers on, sleep, and off mode))	n.a.	http://www.energystar.gov/ia/partners/product_specs/program_reqs/MonitorSpecV4.1.pdf
User Education	Desktops, Notebooks	Include with each computer information on the benefits of power management in either a hard copy or electronic copy of the user manual. At least the following information must be include: • Notice that the computer has been shipped enabled for power management and what the time settings are • How to properly wake the computer from Sleep mode (Harmonized with E* 4.0 for PCs)	n.a.	

Joint Industry Ecodesign Requirements Options for PCs and Monitors (20th March 2007)

Figure 49 Joint Industry Ecodesign Requirements Options for PCs and Monitors ***Note that the sleep and off/standby figures for laptops have been mixed and shall be the other way around.***

A scenario based on the industry proposal is made. The proposal itself and the impact are commented below. The timing for the different requirements described are “allowing for one product redesign cycle” which in the impact calculations is assumed to come in place 2009 and “prolonged transition time (e.g. 4+ years out)” which in the impact calculations is assumed to come in place 2011.

Minimum requirements for monitors´ active power per resolution

EICTA, AeA , JBCE, 2007suggests minimum requirements on active power per mega pixel for monitors. The impact from having minimum requirements for active power consumption for monitors related to the resolution is very small if any. Power is related to screen area, as shown in the background document on monitors (to be included in task 4-5 in the final report). For some technologies, such as plasma screen it is also related to the resolution, but this is not the case for LCDs, which is the most common technology for monitors today. A requirement based on power per resolution will then possibly lead to that, for example, large monitors with low resolution have difficulties to comply. In principle a higher resolution could be provided with a view to achieve compliance. This could possibly lead to extra cost with little extra performance benefit. However, this risk is mainly related to large monitors for whom high resolution is NOT needed, e.g. products to be looked at from a distance, such as media computer monitors.

Minimum requirements for personal computers´ sleep and standby power

Industry [EICTA, AeA , JBCE, 2007] suggests the following minimum sleep and off requirements for desktops and laptops.

Table 139 Industry's suggestion for minimum requirements for personal computers´ sleep and standby power

Mode Timing	**Effective 2009**	**Effective 2011**	
	Desktops and Laptops	Desktops	Laptops
Sleep (S3)	10 W Shipped with energy management enabled, entering low power state after 30 minutes of inactivity	4 W/4.7 W	1.7 W/2.4 W
Off/Standby (S4/S5)	5 W	2 W/2.7 W	1 W/1.7 W

To get an idea of the impact of industry's suggestion for 2009, the levels suggested are compared to data from task 4 given in the tables below.

Table 140 Desktop energy consumption

Data sources / ***Operational modes***	**IVF summer survey**		**Product case data sets**	**Energy Star 2006 data**
	Office desktop	**Home desktop**		
Idle, Average (min – max) (Watt)	73,8 (70,5-78)	61 (50-79,7)	78,2	81,7 (23-221)
Sleep, Average (min – max) (Watt)	3,3 (1,2 - 4,2)	3,7 (2,61-5)	2,2	3,1 (10,1-1,4)
Off, Average (Watt)	1,4 (1 – 2,3)	1,4 (0,7-3)	2,7	2,0 (10,1-0,4)

None of the desktops in the IVF summer survey or in the Product case data sets, representing the best-sellers in 2005, are even close to exceeding the suggested minimum requirement effective 2009: 10 W in sleep and 5 W in standby mode. The Energy Star 2006 data (largely major brands/suppliers) represents more than 100 different models. Among those, only two exceed 10 W in sleep (10,1 W) and three exceed the 5 W standby level. On the other hand, the suggested minimum levels may have some effect on the 10-35% of the desktop market held by so called "White boxes", see Task 2, but due to lack of information available on this market segment it is impossible to quantify the effect. The same observations hold for the notebook market.

Table 141 Laptop energy consumption.

Data sources / ***Operational modes***	**IVF summer survey**		**Product case data sets**	**Energy Star 2006 data**
	Office laptop	**Home laptop**		
Idle, Average (min – max) (Watt)	25,7 (18-34,6)	22,6 (17-34,2)	22,0	19,5 (6,8-38,1)
Sleep, Average (min – max) (Watt)	3,2 (1,7-7,7)	2,3 (0,5-5,0)	4,9	1,4 (0,3-3,5)
Off, Average (Watt)	1,6 (0,3-3)	1,4 (0,28-3)	1,2	0,9 (0,1-2,4)

Industry's suggestion for 2011 correlates exactly with the criteria for Energy Star 4.0 Tier 1 becoming effective 20 July 2007 as far as sleep and standby are concerned. Wake on LAN capability gives an extra 0.7 W allowance in all modes. The Energy Star 4.0 Tier 1 levels were determined by using the Energy Star 2006 data, see tables above, in such a way that approximately 25% of the models should be able to qualify in all modes.

However, 91% and 76% of the desktop models fulfilled the standby and sleep modes; i.e. consumed less than 4 Watt in sleep (91%) and 2 Watt in off/standby (76%) mode respectively. The data from IVF summer survey and Product case data sets, representing the best sellers in 2005 suggest that most desktops (approx. 80%) sold that year fulfilled these criteria. Therefore minimum requirements at these levels will decrease the power consumption per desktop (in particular white box sector), but, considering that the sleep and standby phase 2005 were only 10% of the total use phase consumption, the total energy efficiency gains are limited.

The Energy Star 2006 data suggest that 81% of 2006 laptop models could meet the Energy Star low power mode criteria; i.e. consumed less than 1,7 Watt in sleep and 1 Watt in standby mode respectively. However, the data from IVF summer survey and Product case data, representing the best sellers in 2005, suggest that the average laptop sold that year did not meet the Energy Star criteria. The conclusion is that the minimum requirements at the levels suggested by Industry for 2011 will on average decrease the power consumption per laptop in sleep and off/standby by approximately 1 Watt.

The conclusion is that industry's suggestion for 2011 regarding sleep and off, if implemented, would maintain or slightly decrease the power consumption of desktops and laptops in sleep and standby modes compared to the levels of 2005 and 2006. However, viewed in the context of also requiring enabled power management, industry's suggestion would also effect the power consumption presently allocated to the idle mode. In task 7 is estimated that improved power management could result in around 40% reduction of the total power consumption.

Minimum requirements for Power Supply unit efficiency

Most desktops currently on the market meet industry's recommendation for how efficient an internal power supply should be by 2009. There is a trend towards higher efficiency PSU. The recommendation may impact in particular the 10-35% of the desktop market held by "White boxes", see Task 2. However, again due to lack of information on this market segment it is impossible to quantify the effect reliably. The requirements suggested for the prolonged transition time (2011) are expected to lead to the energy savings for desktop computers shown in figure below. The expected energy savings for laptops applying the suggested power supply efficiency requirements for 2009 for external power supplies are also shown. Power supplies for Monitors is not included in the industry recommendation.

Mandatory enabling of Power management at system level

Mandatory enabling of power management before shipping the product is recommended by the industry. Some studies made by the industry (and shared with the Lot 3 under NDA) show that for products with an enabled power management system, less than 20% of the users turn it off, leading to a much higher use of such a system than if the user have to actively enable it. Information/User education about how to use the power management system should also be provided. Suggested settings for the power management is:

- 15 min to screen off (display sleep)
- 30 min to computer sleep (System Level S3, suspended to RAM)
- Impact of the scenario proposed by Industry.

Impact of scenario 5. Industry recommendation for implementing measures

The main assumptions for the calculations are:

- Energy Star requirements is implemented as assumed in Business as usual I scenario
- Power management at the described settings is assumed to become mandatory enabled 2009, leading to that 80% of products use power management as suggested by EICTA, AeA and JBCE
- High efficient power supply units for desktops becomes mandatory 2011, and for laptops 2009

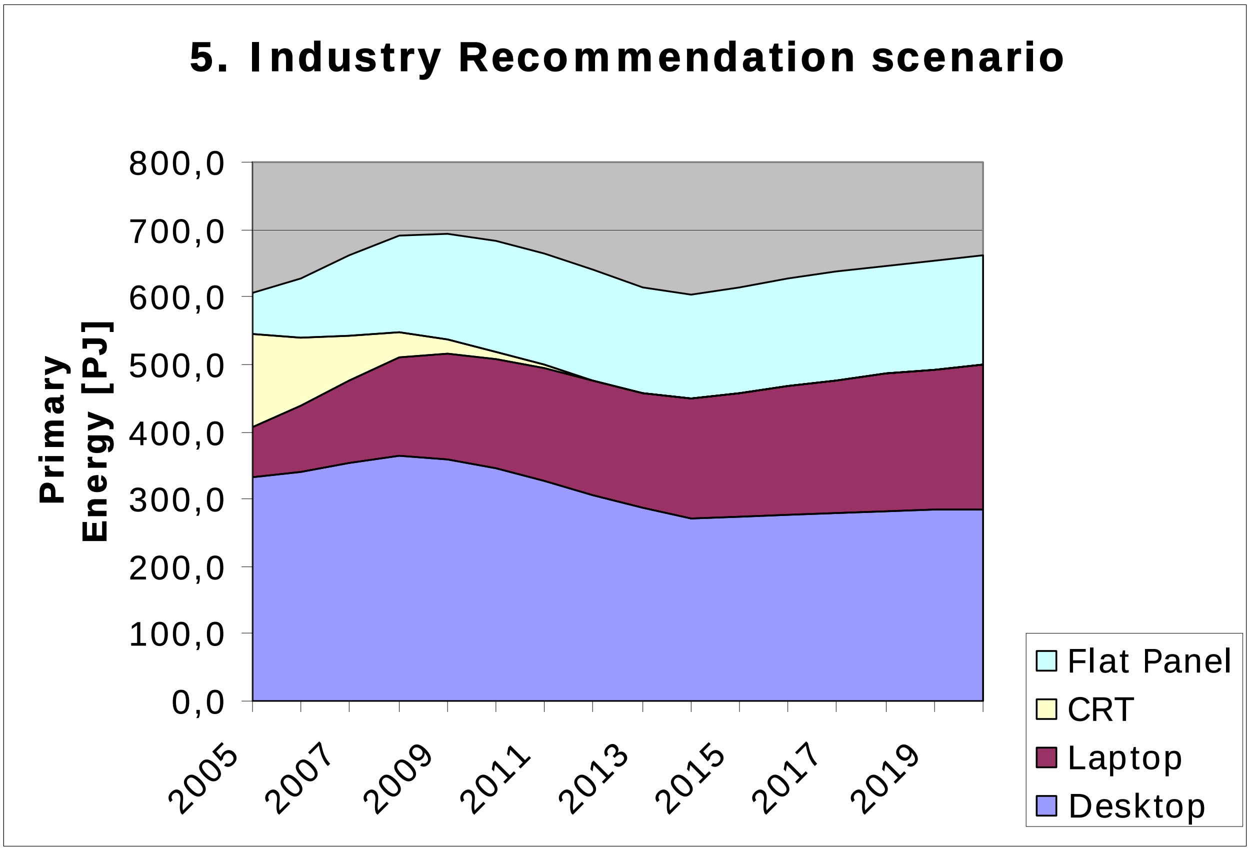

Figure 50 Primary Energy (PJ) Scenario following EICTA, AeA, JBCE 2007

Table 142 Primary Energy (PJ) for Scenario following EICTA, AeA, JBCE 2007.

	5. Industry recommendation					
	Desktop	Laptop	CRT	Flat Panel	Monitors	Summa
2005	331,4	76,4	138,2	60,1	198,3	606,2
2006	340,5	97,3	100,7	88,3	189,0	626,8
2007	353,8	121,7	67,8	117,7	185,5	661,0
2008	364,9	144,3	38,4	144,6	183,0	692,1
2009	357,6	159,1	20,3	156,8	177,1	693,8
2010	345,2	163,2	10,1	164,3	174,4	682,8
2011	326,1	168,9	4,0	166,3	170,3	665,3
2012	306,8	168,9	1,2	163,3	164,5	640,2
2013	287,8	168,6	0,0	158,1	158,1	614,5
2014	271,7	177,1	0,0	153,3	153,3	602,1
2015	273,8	184,4	0,0	156,8	156,8	615,1
2016	276,1	191,2	0,0	159,2	159,2	626,5
2017	278,8	198,0	0,0	160,7	160,7	637,5
2018	281,2	203,9	0,0	161,5	161,5	646,7
2019	283,2	209,4	0,0	162,1	162,1	654,7
2020	284,5	214,1	0,0	162,2	162,2	660,9

- From the figure above, it is obvious that industry's recommendation have an impact on the energy used, compared to the business as usual scenario. The main difference is due to power management enabling, and the more efficient power supply units.

8.1.9 Comparison between the different scenarios for the products one by one

To be able to compare the different scenarios for one product at the time, the following graphs are included.

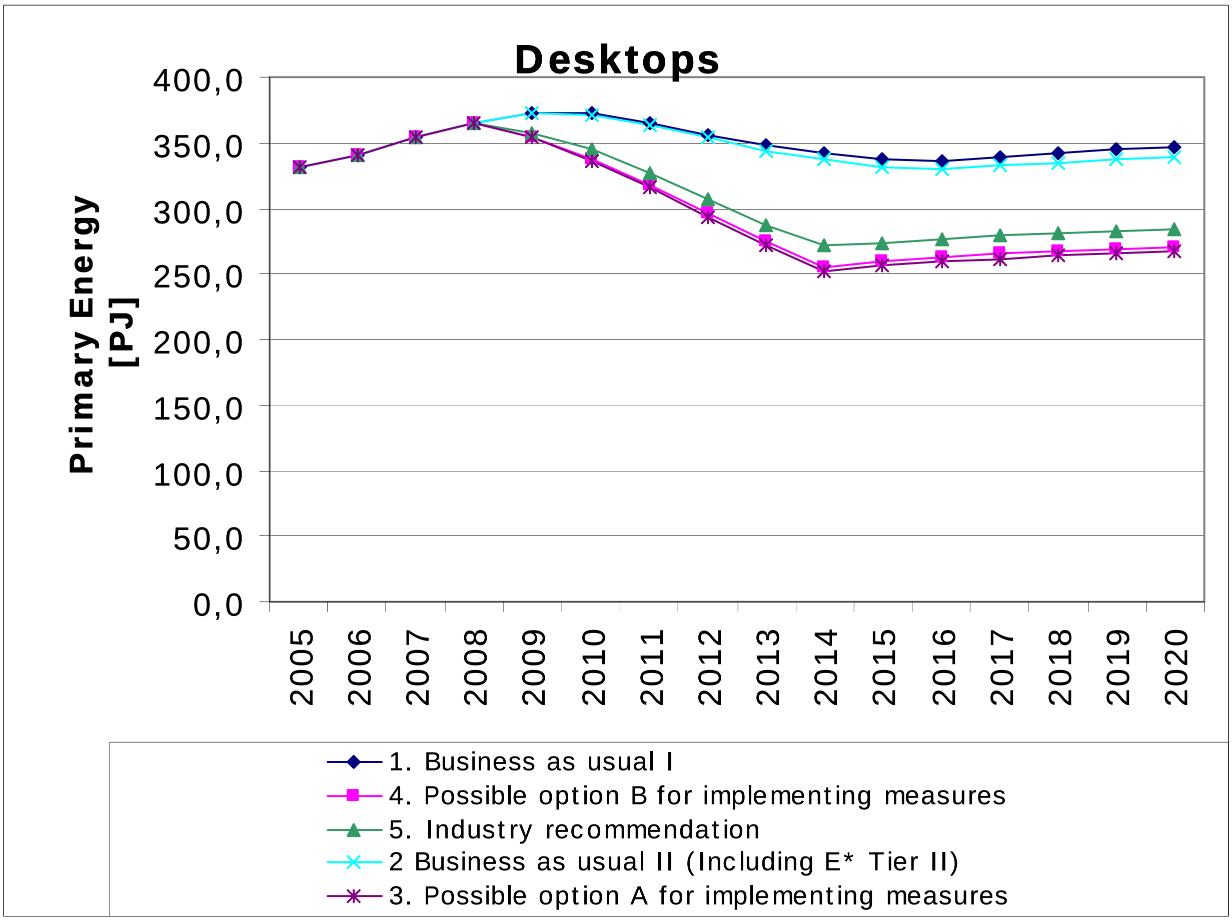

Figure 51 The different scenarios described for desktops. Note the difference in timing for implementing efficient power supply units between possible options A&B and Industry recommendation. Half of the difference between Business as usual scenarios and other scenarios is due to the implemented power management in the latter. The discontinuities are depending on the time to implement a feature in the whole stock. The idle-on requirement for computers give the best scenario, followed by the information requirement scenario, both including enabled power management and power supply efficiency requirements. Industry recommendation does mainly include enabled power management and power supply efficiency requirements.

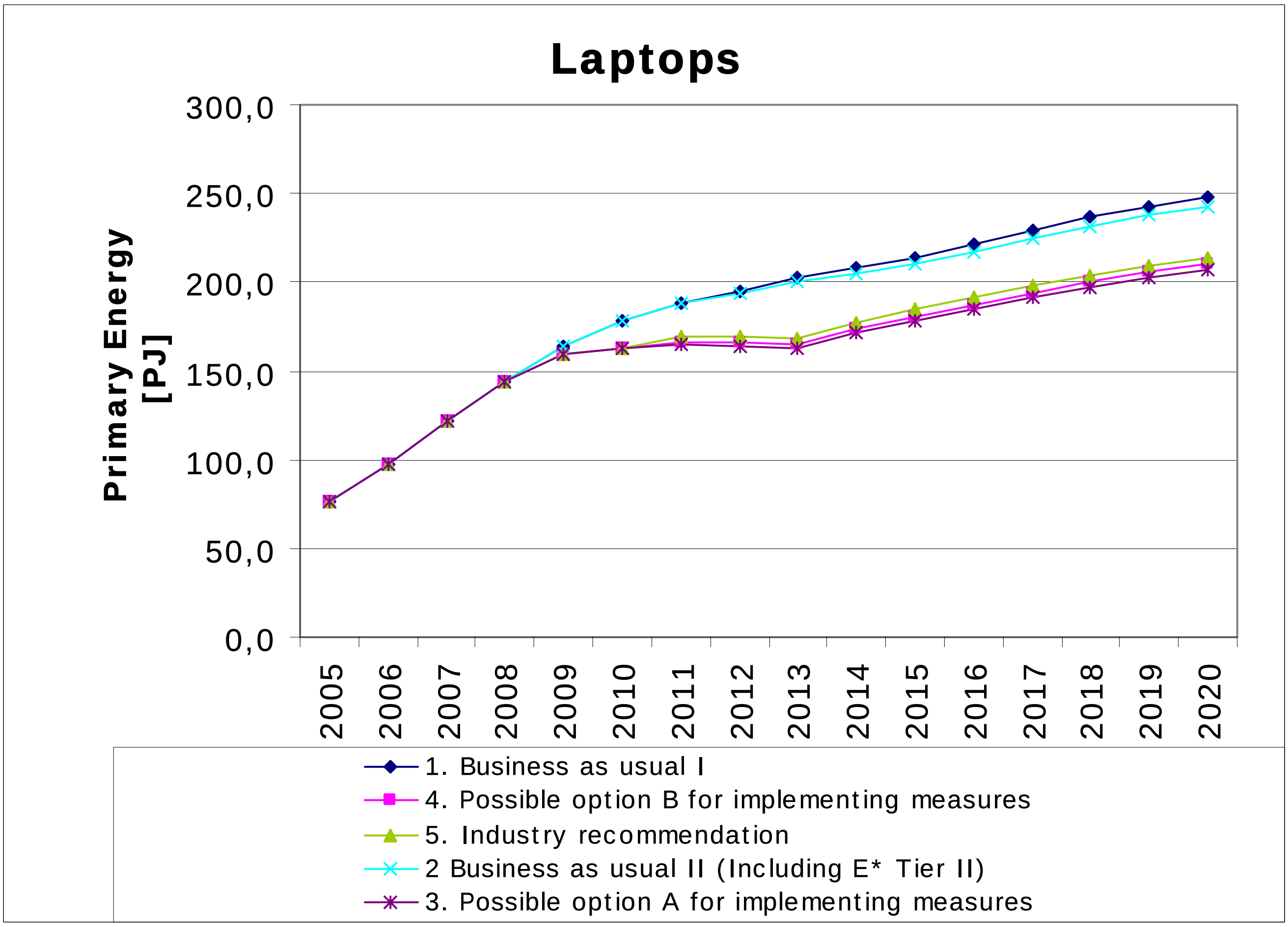

Figure 52 The different scenarios described for laptops. The main difference between the business as usual scenario and the three others is due to enabled power management requirement in the latter.

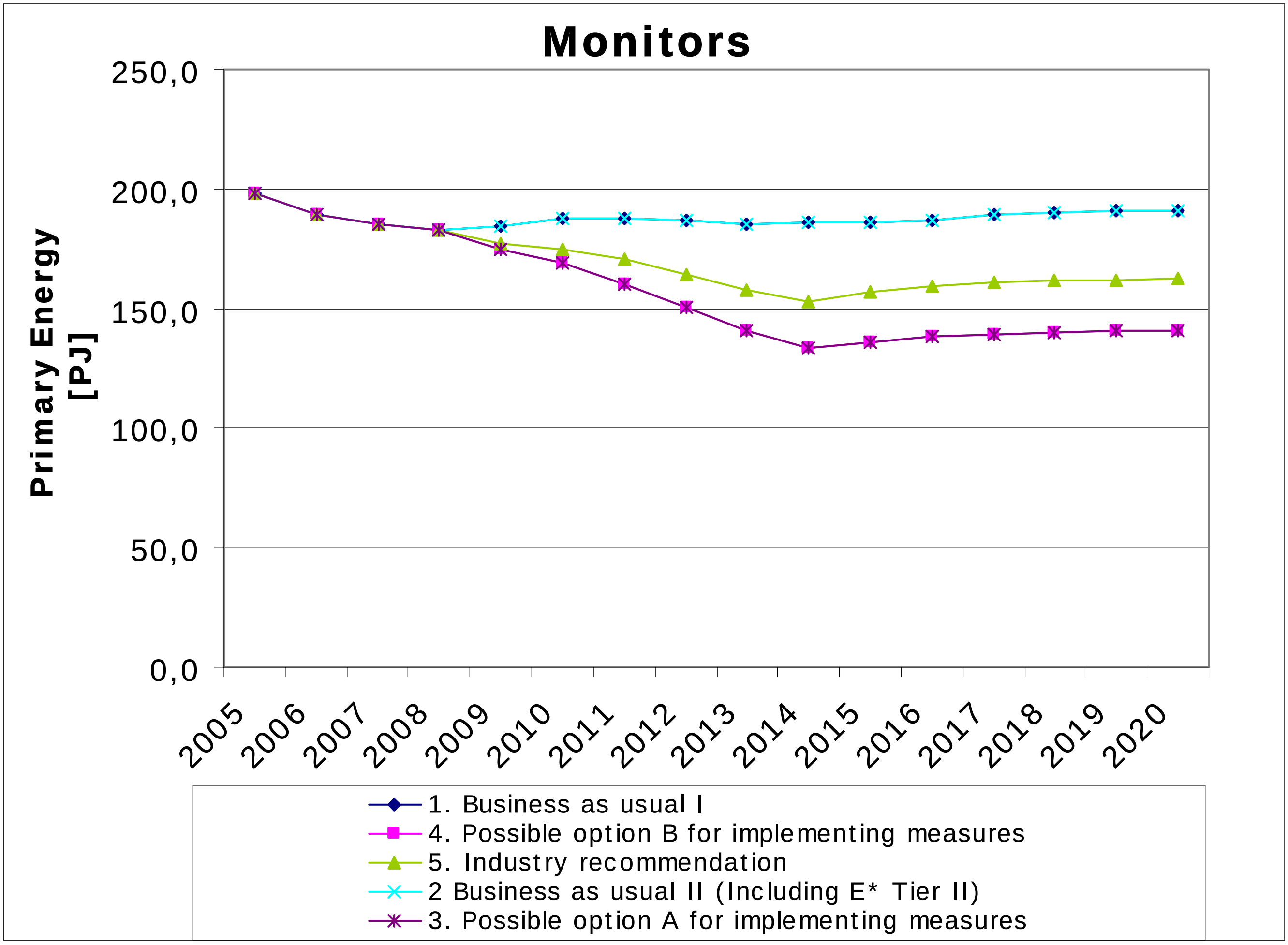

Figure 53 The different scenarios described for monitors. Note the difference between the possible options A&B and the Industry recommendation, based on that the Possible options include a high efficient power supply unit even for monitors from 2009 and a power per area requirement from 2011. The discontinuities are due to the timing from implementation until the whole stock is changed.

8.1.10 Study recommendation

The Lot 3 study recommends to implement scenario 4, Possible option B, since that scenario is based on least life cycle cost, gives a huge positive impact on energy consumption, and is not blocking technology development.

8.1.11 Possible measures not recommended by the study

In recently introduced circuit technology, several functions for saving of energy have been introduced at chip level. Examples are “reduction of clock frequency when full power is not needed”, “reduction of voltage when full power is not needed” and “multiple processor cores in one chip, of which only the necessary number are used in a specific moment”. Each of these technologies, are effective.

However, requirements would be technology specific and could lead to obstacles for the development of better technologies.

8.1.12 Additional suggestions

The following suggestions are not following directly from applying the MEEuP methodology, but are anyhow based on the experiences gained when carrying out the study.

Research: User behaviour study, Personal Computers and Monitors

In order to better understand the usage pattern, and to further develop energy efficient equipment, there is a need to study the usage pattern for computers and computer monitors. Available reports are often old, and the usage tends to change when new applications are available, such as Internet gaming, online bank offices, telephoning or movie watching over the computer. Studies available is often based on questionnaires rather than measuring (logging) the behaviour, which gives less reliable results. There is at least one study of good quality available, but that study only covers a small geographic area compared to the whole EU, and only home users. Thus, there is a need to make a larger study. The suggested study should use logging methods and/or “ping” technologies in order to measure the true usage pattern in different modes. It should cover at least users in all the countries and also different kind if users, such as office/home, different age, sex, interests etc. It can be complemented with a survey where the users are asked questions, in order to better understand underlying causes of their behaviour. Such a study would aid in the development of new computer systems.

Education

The consumer behaviour has a large impact on the environmental performance of products evaluated in this study. One option with a large improvement potential not discussed earlier could therefore be consumer education. Education could help users to understand and use power management in a proper way, and could also offer guidance in purchasing choices. Education can be delivered in many ways; such as implementing easy access tutorial tools integrated in the computer software or at a website. Another solution might be to educate all pupils at school, to provide them with a “driving license for computers”. The impact of such education could be huge.

Software development

The performance of software is not within the real scope of this study, but since the effects on the environmental impact and LCC of computer products are quite significant it is still worth to comment.

The potential positive influence from power management, have been covered in several of the previous chapters, but it is also obvious that the full potentials of the hardware power management functions, very seldom are utilized due to software problems or even perceived software problems.

The recently introduced operating system Vista includes much more powerful power management functionality than the previous operating systems, but due to the increased demands for computer capacity for other functions, environmental improvements attributable to Vista is questionable.

The increased capacity and functionality from new software is obvious: more graphics, easier to use, better integration of different applications and so on. But seen from another standpoint: real improvements in capacity versus increased demands for computing power are not that positive. The documents written in a brand-new word-processor are not that much better than the documents written a couple of years ago using much less computing power and energy.

The potential for better LCC from dedicated software development with energy efficiency in focus is quite high, but it has probably not yet become a strong enough selling argument, to influence the new products.

Implementing measures on other things than energy

Besides energy consumption, the further major environmental issues to deal with for the products studied are the

- Content of flame retardants in plastics and electronics
- Content of mercury in the lamps for LCD screens and laptops
- Content of chemicals in the batteries of laptops.

The analysis of the environmental parameters has shown that the by far most significant aspect is energy consumption; the improvement options and implementing measures recommended by the study are focused on reduced energy consumption. Other improvement options described in task 6-7 are concerning further impacts regarding other things. The recommendation is to include information about specific restricted substances such as mercury and lead in the information about the product, see chapter 1.1.7. Regarding the flame-retardants, and possibly also the chemical content of the batteries for laptops, this should be handled under the RoHS-directive on a substance-by-substance basis. New chemicals should be handled by the REACH-directive.

8.2 Sensitivity analysis of the main parameters

The calculations carried out in this preparatory study should serve dual purposes: one is to assess the total energy consumption and environmental impact in EU25 from personal computers and monitors, the other is to give knowledge about design options that could reduce the environmental impact with focus on energy consumption. The most significant data aspects and assumptions and how they have been dealt with in the study are:

- Market data from different sources is not fully consistent, which required some principle estimations. However, the data has been discussed intensively with the stakeholders and they are in agreement.
- Use patterns vary a lot and there are no complete studies covering all users in EU 25. Also regarding the service life of a computer, no comprehensive data was available. The impact of uncertainties in use patterns and service life are shown below in the sensitivity calculations.
- The idle power values used in the base-case calculations are only indicators of the true power values during use of the computers and therefore uncertain. The impact of this uncertainty is shown below in the sensitivity calculations.
- The base cases are as required by the methodology a “conscious abstraction of reality” but cannot claim to be in a scientific statistical sense representative. We have used data for the best sellers, but not qualified to which degree these data really reflects the average. The chosen number of base cases contributed to the overall robustness of the results for individual segments.
- Data on power use and BOM when provided by manufacturers has not been empirically verified, but inconsistencies have been clarified with the data providers.
- The “base case” results can only reflect assessments on the level on which the EcoReport requires entries (e.g. no differentiation of substrate materials, no differentiation of electronic component compositions, no entries / analyses of hazardous materials foreseen such as flame retardants). Some basic data, e.g. for batteries, is completely missing. Correct evaluation of LCD screens without mercury (with LED-backlights) is impossible.
- Electronics design is a comprehensive task with a huge number of variables. To come to precisely quantified effects of technical improvement options taking into account the variety of possible specifications as well as of electrical parameters is not feasible. The conclusions described in task 7 should therefore be considered valid (and robust with the three exceptions described below) in the general case. For a single computer or monitor specification, deviations from the conclusions should always be expected and investigated.

8.3 Sensitivity calculations

The Ecoreport tool is not suited for common types of sensitivity analysis in life cycle assessment, e.g. how the electricity is produced or how materials are produced. Therefore the sensitivity analysis is limited in scope.

As mentioned before, the uncertainties are large concerning usage patterns. In addition, the idle power values used in the base-cases calculations are only indicators of the true power values during use of the computers and therefore uncertain. Usage pattern uncertainties, uncertainties in power values and uncertainties about the service life time can be treated together as uncertainty in the energy used when using the computer/monitor, since energy = power * time. There are also large variations in the price of electricity between different EU countries. These aspects, variations in energy and price of electricity, are highlighted below with the aid of the EcoReport tool.

For the improvement options described in task 7, the parameters are varied within the uncertainty intervals. Life cycle cost and impact is compared to the base case calculations. It is shown below that the conclusions about the improvement options are robust for all improvement options except 80+PSUs in home laptops and home LCDs, in interval –50% to +50% on the price of electricity and –50% to +100% in electric energy during use.

8.3.1 Use electricity

The energy used when using the computer/monitor is electricity taken from the national grid. It will henceforth be referred to as Use electricity. Use electricity is varied between –50% to +100%.

The reason for having an unsymmetrical span is that the idle power value is only a minimum indicator of the true power during use. It cannot be smaller, only larger. As explained above, variations in Use electricity can represent variations in power and/or time the computer or monitor is on in the different modes and/or service lifetime. Since most energy is used in the idle power mode, see figure below, there is a limit to how much of the variation that can be attributed to the sleep and off modes.

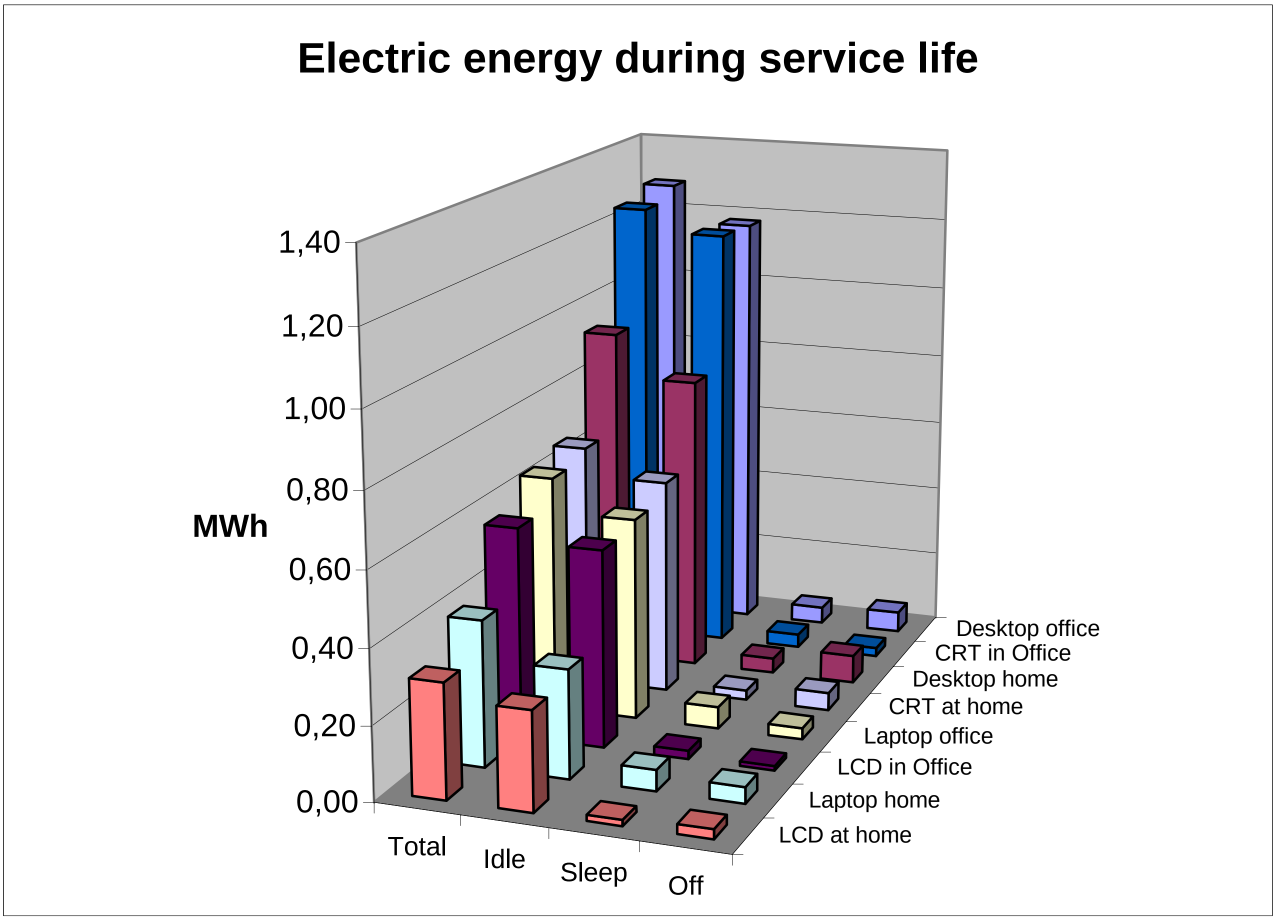

Figure 54   Energy use during service life for all the products, and use modes

The Ecoreport calculates the Use electricity as:

> Use electricity = Product life in years * (Idle/On hours per year * Idle/On power + Sleep hours per year * Sleep power + Off hours per year * Off power)

In the table below is shown in absolute figures for an office LCD-display how much the parameters Product life, On power and On hours can vary (everything else remaining constant) to depict –50% Use electricity and +100% Use electricity. Variation between usage pattern studies, see Task 3, is in that order of magnitude. Variations in Product life and Idle/On power are assumed to be in the order of plus/minus 10-20%, i.e. much less.

Table 143 Example of what the Use electricity uncertainty span may represent

	-50%	Base case	+100%
Product life (years)	3,3	6,6	12,4
On power (kW)	~15	31,4	~64
On hours per year	~1200	2586	~5400

In the sensitivity calculations, Use electricity is modelled by varying the hours in the modes idle/on and sleep. Results for the improvement options are given in the table below.

Since all improvement options reduce the amount of Use electricity needed and thus save more electricity cost the more energy is used, the plus 100% alternative would always make the improvement options more attractive both economically and environmentally. Therefore the improvement options are not calculated with the plus 100% alternative. Furthermore, since there is no extra cost associated with improved power management, this option would always (both at minus 50% Use electricity and at plus 100% Use electricity) be more attractive both economically and environmentally. Therefore, the power management option is excluded from the sensitivity calculations.

When the Use electricity is decreased the improvement options gets less economically and environmentally attractive. Cases where the improvement option with the minus 50% alternative does not get least life cycle cost are highlighted in the table below. This happens only for home laptops and LCDs fitted with 80+ PSU and the difference is very small. This means that the conclusions about 80+ PSU in home laptops and LCDs giving least life cycle cost are not as robust. But all the other conclusions about the improvement options are robust, at least in the interval –50% to +100% Use electricity.

Table 144 Sensitivity calculations at product level varying Use electricity

Improvement	Parameters	Use electricity (MWh)			Life cycle cost (Euro)		
		-50%	Used values	+100%	-50%	Used values	+100%
Office desktops	No option (base case)	0,64	1,28	2,56	818	900	1062
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,52	1,03	2,06	808	873	NA
	Improved processor	0,50	0,99	1,98	811	872	NA
	PM at processor level	0,54	1,08	2,16	806	875	NA
Home desktops	No option (base case)	0,47	0,93	1,86	697	756	NA
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,38	0,75	1,50	690	738	NA
	Improved processor	0,37	0,73	1,46	694	740	NA
	PM at processor level	0,40	0,8	1,60	688	738	NA
Office laptops	No option (base case)	0,28	0,55	1,10	1396	1430	1501
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,21	0,42	0,84	1392	1419	NA
Home laptops	No option (base case)	0,17	0,34	0,68	1129	1151	1195
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,13	0,25	0,50	1130	1145	NA

Improvement	Parameters	Use electricity (MWh)			Life cycle cost (Euro)		
		-50%	Used values	+100%	-50%	Used values	+100%
Office LCD	No option (base case)	0,29	0,57	1,14	238	274	NA
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,23	0,46	0,92	236	265	NA
Home LCD	No option (base case)	0,16	0,31	0,62	221	240	280
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,13	0,25	0,50	223	238	NA
Office CRT	No option (base case)	0,63	1,25	2,50	154	232	391
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,50	1,00	2,00	142	205	NA
Home CRT	No option (base case)	0,34	0,67	1,34	116	158	243
	Power management	NA	NA	NA	NA	NA	NA
	80+PSU	0,27	0,53	1,06	112	146	NA

The table above shows that all the conclusions about the improvement options in Task 7 are robust, in the interval –50% to +100% Use electricity, except the conclusions about 80+ PSU in home laptops and LCDs (highlighted) which are robust until very extreme values.

8.3.2 Electricity price

Electricity prices are varied 50% up and down to reflect price variations in Europe. The electricity price for the base-case was 0,136 Euro/kWh. The uncertainty interval is thus in absolute figures 0,136 +/- 0,068, i.e. 0,068 Euro to 0,204 Euro per kWh. The results for the improvement options are given in the table below.

Since all options reduce the amount of Use electricity needed and thus save more electricity cost the higher the electricity price is, the plus 50% alternative would always make the improvement options more attractive economically. Therefore the improvement options are not calculated with the plus 50% alternative. Furthermore, since there is no extra cost associated with improved power management, this option would always be more attractive economically as long as something is paid for the electricity. Therefore, the power management option is excluded from the sensitivity calculations.

When the electricity price is decreased the improvement options gets less economically attractive. Cases where the improvement option with the minus 50% alternative does not get least life cycle cost are highlighted in the table below. This happens only for 80+PSUs in home laptops and home LCDs. This means that the conclusions about 80+ PSU in home laptops and LCDs giving least life cycle cost are not that robust. But all the other conclusions about the improvement options are robust in the interval –50% to +50% on the price of electricity. This is the same robustness result as for uncertainties in Use electricity above.

Table 145 Sensitivity calculations at product level varying electricity price

Improvement	Parameters	Life cycle cost (Euro) at varying electricity price	
		-50% (0,068 E/kWh)	Used values (0,136 E/kWh)
Office desktops	No option (base case)	818	900
	80+PSU	807	873
	Improved processor	810	872
	PM at processor level	806	875
Home desktops	No option (base case)	696	756
	80+PSU	690	738
	Improved processor	693	740
	PM at processor level	688	738
Office laptops	No option (base case)	1395	1430
	80+PSU	1392	1419
Home laptops	No option (base case)	1129	1151
	80+PSU	1129	1145
Office LCD	No option (base case)	237	274
	80+PSU	235	265
Home LCD	No option (base case)	221	240
	80+PSU	222	238
Office CRT	No option (base case)	152	232
	80+PSU	142	205
Home CRT	No option (base case)	115	158
	80+PSU	112	146

8.3.3 EU-25 level

In the Table below is shown how variations in Use electricity would influence the results at EU-25 level at present.

Table 146 Sensitivity calculations at EU-25 level varying Use electricity

Improvement	Parameters	Use electricity per product (MWh)			Total primary energy (PJ)		
		-50%	Used values	+100 %	-50%	Used values	+100 %
Office desktops	No option (base case)	0,64	1,28	2,56	67	112	202
	Products with LLCC	0,21	0,42	0,84	38	52	82
Home desktops	No option (base case)	0,47	0,93	1,86	129	204	354
	Products with LLCC	0,17	0,34	0,68	80	108	164
Office laptops	No option (base case)	0,28	0,55	1,10	36	54	92
	Products with LLCC	0,13	0,26	0,52	26	35	53
Home laptops	No option (base case)	0,17	0,34	0,68	19	26	42
	Products with LLCC	0,10	0,19	0,38	16	20	28

Improvement	Parameters	Use electricity per product (MWh)			Total primary energy (PJ)		
		-50%	Used values	+100 %	-50%	Used values	+100 %
Office LCD	No option (base case)	0,29	0,57	1,14	19	28	47
	Products with LLCC	0,13	0,26	0,52	14	18	27
Home LCD	No option (base case)	0,16	0,31	0,62	34	46	69
	Products with LLCC	0,08	0,15	0,30	28	34	45
Office CRT	No option (base case)	0,63	1,25	2,50	26	49	97
	Products with LLCC	0,27	0,55	1,10	12	23	44
Home CRT	No option (base case)	0,34	0,67	1,34	35	64	126
	Products with LLCC	0,16	0,32	0,64	19	33	62
Total	No option (base case)				**365**	**583**	**1029**
	Products with LLCC				**233**	**323**	**505**

In the figure below is shown how variations in Use electricity would influence the results at EU-25 level from 2005 to 2020 assuming a business as usual scenario.

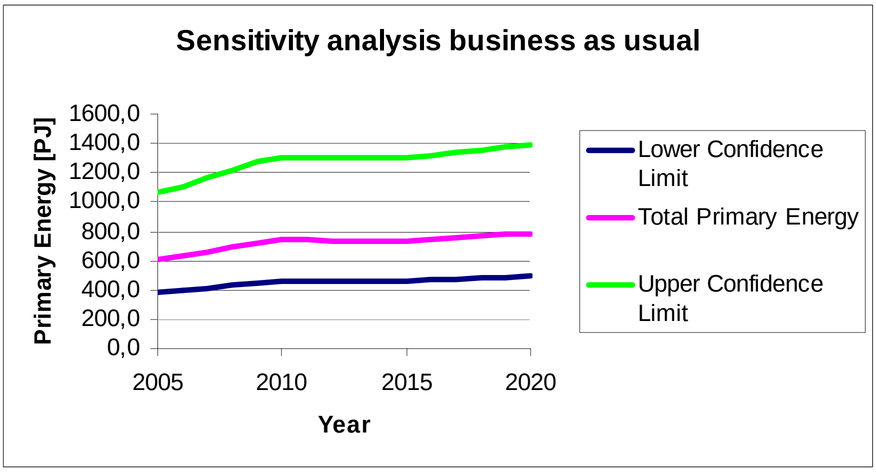

Figure 55 Sensitivity to variations in Use electricity assuming a business as usual scenario

8.3.4 Conclusions from the sensitivity analysis

The most significant data aspects and assumptions have been identified and discussed. To check the robustness of the results against the major insecurities, all conclusions regarding LLCC options, have been recalculated varying the price of electricity between –50% and +50% and the electric energy during use between –50% and +100%, and in general found robust. The results also show that when recalculating the total use of primary energy at EU-25 level for 2005 changing the parameters as described above, the total primary energy consumption from personal computers and monitors will differ between 365 and 1029 PJ. All suggested options for LLCC are robust, and will remain LLCC even if the parameters price and energy use are changed within large ranges as described above.

8.4 References

- Computertechnik, Monitor statistics during the years 1998 to 2006 (German Magazine)
- Energy Star database for monitors, may 2007
- ENERGY STAR® Program Requirements for Computer Monitors Eligibility Criteria (Version 4.1)
- ENERGY STAR® Program Requirements for Computers. Version 4.0
- Implementing measures recommended by the industry; Joint Position paper: Ecodesign Requirements for EuP Study on PCs and Monitors (Lot3). Brussels, March 20th 2007) by EICTA, AeA and JBCE.
- Personal Computers (desktops and laptops) and Computer Monitors Draft Final Report (Task 1-7).

9 Abbreviations used

ACPI Advanced Configuration and Power Interface

Ag, silver

BAT, Best Available Technology

BOM, Bill of Materials

BNAT, Best Not yet Available Technology

CPU Central Processing Unit

CRT, cathode-ray tube

EIA, Environmental Impact Assessment

GER, Gross Energy Requirement. Electricity from the public grid needs 10,5 MJ GER per kWh electricity

GPU Graphics Processing Unit

HDD, Hard Disk Drive

LED, light emitting diode

LLCC, Least Life Cycle Cost

LCD, liquid crystal display

OLED, organic light emitting diode

PSU, power supply unit

PWB, printed wiring board

RAM, Random Access Memory

SMD, surface mounted devices

Sn, tin

10 Appendix 1: Data collection

10.1.1 Choice of product cases

The choice of relevant product cases had the following starting points:

- The product definition from Task 1: "Within the scope of this study are desktops, integrated computers, laptops and computer monitors. What constitutes a desktop, an integrated computer, a laptop and a computer monitor is defined by Energy Star definitions" [Computers, Final Draft Version 4.0 and Monitors, Version 4.1].
- The economic and market analysis from Task 2.
- The different usage patterns for homes and offices analyzed in Task 3
- The stakeholder dialogue, ie:
    - the stakeholder meeting 30 May 2006 at IVF in Mölndal Sweden,
    - the subsequent questionnaire during summer 2006 and
    - the feedback received in October on the tentative choice of product cases
    - the datasets received for the different product cases (including also numerous e-mail and telephone contacts for checking data consistency)

The base-case calculations should serve dual purposes: one is to assess the total energy consumption and environmental impact in EU25 from personal computers and monitors in 2005, the other is to give knowledge about design options that could reduce the environmental impact with focus on energy consumption. Other important considerations in the choice of base-cases are:

- At the stakeholder meeting in Mölndal, the computer industry strongly recommended separate base-cases for PCs for the home and office market respectively.
- The purpose to assess the total energy consumption and environmental impact from personal computers and monitors in 2005 suggests that base-cases should represent the best-sellers[11] in that year
- From energy per unit point of view, the processor is the most essential component[12]. This component is also the most essential from a computer performance point of view.

[11] The VHK-methodology prescribes the use of EU average data. Through the first questionnaire [IVF, July 2006], data covering around 17% of computer sales in 2005 was obtained. They represent the best selling brands and models in Europe.

[12] Battery chargers and external power supplies may also be very important but they are covered in a parallel study, Lot 7 [Lot 7, November 2006]. For laptops, the LCD-screen is an important energy user.

- To follow as closely as possible the most current version of the Energy Star Requirements, with respect to grouping of computers and monitors, because Energy Star is well accepted by both industry and public bodies.

With this background and the above product definition, the following product cases representative for personal computers and monitors sold in 2005 were chosen:

- Laptop for office use[13] with a modern energy efficient processor
- Laptop for home use[13] with a desktop replacement processor[14]
- Desktop high-end, ie with a high-performance processor and graphics card. This could be a high-end desktop for home use even though these are not selling quite as much as value desktops. The high-end desktop is supposed to fall under Energy Star category B[15].
- Desktop office value best seller with single core medium performance processor falling under Energy Star category A[16]. No separate graphics card.
- 17" TN-based TFT LCD
- 17" CRT for office use

Other categories that have been discussed include:

- Workstations, but they fell outside the product definition, and
- High-end desktops meeting specifications for Energy Star category C, but few if any such machines were sold during 2005

10.1.2 Supply of data for product cases

Already at the Mölndal workshop in May 2006, industry declared a willingness to support the study including supplying data. However, it was also clear that data would be supplied only under non-disclosure agreements. Since the study is public, a strategy has been devised to only publish data that has been aggregated to a level where it is not possible to trace any data back to any specific manufacturer.

Since an insufficient number of datasets were received (to enable aggregation as described above), all laptops were aggregated into one case and all desktops aggregated into one case. What this means for the robustness of the conclusions is discussed in Task 8.

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[13] Both laptop base-cases are supposed to fall under Energy Star category A for laptops, ie their GPU have less than 128 Mb of dedicated, non-shared memory.

[14] Desktop replacement processor is the terminology used by industry when a processor designed for desktops is used in a laptop

[15] To qualify under Energy Star category B desktops must have: Multi-core processor(s) or greater than 1 discrete processor and minimum of 1 gigabyte system memory.

[16] All desktops that do not meet the definition of Energy Star category B desktops

Doing a life cycle assessment, LCA, with any software tool involves doing a number of assumptions about materials, volumes, processes etc because the data available is always limited. Doing an LCA with the EuP EcoReport is no exception. To ensure that all these assumptions are done in something close to a uniform way, one person should feed the data into the tool. This person must of course make the assumptions in a consistent way. Therefore industry has been asked to supply data in a form fitting the EuP EcoReport[17], but not feed data themselves into the tool. To this end a questionnaire containing 21 questions related to data on specific product cases was designed and sent out to industry 11 November 2006. The questionnaire is given in Table 83.

Table 147 Questionnaire for provision of LCA data.

Question		**Your answer**
1. Name of product		
2. E-mail and telephone number to person who can give more information about the data provided		
3. How many of this product was sold in 2005 in EU 25?		
4. State accessories that are included, such as keyboard, mouse, display		
5. Average price to customer in EU25 in 2005 in Euro		
6. Processor (Brand, model, (speed GHz))		
7. Graphic card built-in or separate and name of graphic card		
8. Size (Width [mm]/Depth [mm]/Height [mm]) and shape (tower, microtower, etc) of product		
9. Volume of packaged final product in m^3?		
10. Weight of product [kg]?		
11. Power consumption [W] during idle mode, (measured according to Energy Star version 4.0)		
12. Power consumption [W] during sleep mode, (measured according to Energy Star version 4.0)		
13. Power consumption [W] during off-mode (hibernate/stand-by/soft off), (measured according to Energy Star version 4.0)		
14. An estimate of number of transport kilometers over product-life used for services and repairs?		
15. How many grams of the	LDPE[19]	
	HDPE[20]	

[17] See http://ec.europa.eu/energy/demand/legislation/doc/eup_ecoreport_v5_en.xls for the EcoReport.

Question		**Your answer**
1. Name of product		
following bulk plastics does the product contain as shipped[18]?	LLDPE[21]	
	PP[22]	
	PS[23]	
	EPS[24]	
	HI-PS[25]	
	PVC	
	SAN[26]	
	ABS[27]	
	Other, please specify	
	Other, please specify	
	Other, please specify	
16. How many grams of the following technical plastics and fillers does the product contain as shipped[18]?	PA 6[28]	
	PC[29]	
	PMMA[30]	
	Epoxy	
	Rigid PUR[31]	
	Flex PUR	
	Talcum Filler	
	E-glass fibre	
	Aramid fibre	
	Other, please specify	
	Other, please specify	
	Other, please specify	
17. How many grams of the following ferro metals does the product contain as shipped[18]?	Steel sheet galvanized	
	Steel tube/ profile	
	Cast iron	
	Ferrite	
	Stainless 18/8 coil	
	Other, please specify	
	Other, please specify	

[18] including packaging, manuals etc
[19] Low Density Poly Ethylene
[20] High Density Poly Ethylene
[21] Linear Low Density Polyethylene
[22] Polypropylene
[23] Polystyrene
[24] Expanded polystyrene
[25] High impact polysterene
[26] Polystyrene acrylonitrile)
[27] (Poly) Acrylonitrile Butadiene Styrene
[28] Polyamide
[29] Polycarbonate
[30] Polymethylmethacrylate
[31] Polyurethene

Question		**Your answer**
1. Name of product		
	Other, please specify	
18. How many grams of the following non-ferro metals does the product contain as shipped[18]?	Al sheet/ extrusion	
	Al diecast	
	Cu winding wire	
	Cu wire	
	Cu tube/sheet	
	CuZn38 cast[32]	
	ZnAl4 cast[33]	
	MgZn5 cast[34]	
	Other, please specify	
	Other, please specify	
	Other, please specify	
19. How many grams of the following coatings does the product contain as shipped[18]?	Pre-coating coil[35]	
	Powder coating	
	Cu/Ni/Cr plating	
	Au/Pt/Pd plating	
	Other, please specify	
	Other, please specify	
	Other, please specify	
20. How many m^2 screen does the product contain as shipped[36]?	LCD screen m^2 (viewable screen size)	
	CRT screen m^2 (nominal screen size)	
21. How many grams of the following electronics does the product contain as	Big caps & coils[37]	
	Slots /ext. ports[38]	
	Integrated Circuits, 5% Silicon, Au[39]	
	Integrated Circuits, 1% Silicon[39]	

[32] 38% Zink

[33] 4% Aluminium

[34] 5% Zink

[35] Pre-coated steel or aluminium sheet metal

[36] For computers: Only applicable when screen is integrated or part of shipment. The glass in the LCD and the lead and glass in the CRTs should not be specified elsewhere. No double-counting of these materials!

For monitors: The glass in the LCD and the lead and glass in the CRTs should not be specified elsewhere. No double-counting of these materials!

[37] Large capacitors and coils components on a printed wiring board typical for power conversion functions.

Question		Your answer
1. Name of product		
shipped[18]?	SMD & LEDs avg[40]	
	PWB ½ lay 3.75 kg/m2[41]	
	PWB 6 lay 4.5 kg/m2[42]	
	PWB 6 lay 2 kg/m2[43]	
	Solder SnAg4Cu0.5[44]	
	Other, please specify	
	Other, please specify	
	Other, please specify	
22. How many grams of the following materials does the product contain as shipped[18]?	Glass for lamps	
	Bitumen	
	Cardboard	
	Office paper	
	Concrete	
	Other, please specify	
	Other, please specify	
	Other, please specify	
For further explanation of the above questions and abbreviation used, please see The MEEUP Methodology Report pages 88-89 and 93-97 or contact Mats.Zackrisson@ivf.se, telephone +46 8 20 39 53.		

10.1.3 Data assumptions

For received data not fitting the EcoReport format, assumptions presented in this appendix have been used consistently in the study. Names in *italics* correspond to material names in the EuP EcoReport, see MEEUP Methodology Report pages 88-89 and 93-97 and/or the EuP EcoReport.

1. Unspecified ferrous&non-ferrous metal assumed to be equivalent to 90% *galvanized steel* and 10% *Al sheet*, because it represents a likely worst case (in primary energy)

2. Unspecified plastics assumed to be equivalent to *PA 6*, because it represents worst likely case (in primary energy)

[38] Printed wiring board mounted slots for RAM-chips, PCI-cards and external ports

[39] The two integrated circuits represent extremes of the current range of integrated circuits. The 5% Silicon with gold content represent a large IC including memory, the 1% silicon represents a small surface mounted type IC

[40] Surface mounted devices such as diodes, thyristors, RF etc

[41] Standard FR4 printed wiring board

[42] Multilayer standard FR4 printed wiring board

[43] Multilayer printed wiring board with microvias

[44] Lead-free tin solder with 4% Ag and 0,5% Cu

3. Non-recyclable Plastic assumed to be equivalent to the thermoset *epoxy* that cannot be recycled

4. The distribution between coat and material on coated objects is based on 100 µm on 1 mm sheet steel, where the distribution between materials is: =100/1000000*1*1490/7800/1/0.001 = 2% pulver, ie 98% material.

5. Wires and cables internal assumed to be equivalent to *Cu wire*

6. External Electric cables assumed to be equivalent to 80% *Cu wire* and 20% *PVC*.

7. 17" CRT with 4/5 relationship between sides (1280*1024)[45] corresponds to 910 cm2 nominal surface (17*2.54=43.18; $(5^2+4^2)^{1/2}$=6.4; 43.18*5/6.4=33.73; 43.18*4/6.4=26.99; 26.99*33.73=910 cm2= 0.0910 m2. Same for LCD but actual viewing surface. 1000*0.091 inserted in the EcoReport!

8. 15.4" LCD with 8/5 relationship between sides (1280*800)[46] corresponds to 688 cm2 nominal surface (15.4*2.54=39.12; $(8^2+5^2)^{1/2}$=9.43; 39.12*8/9.43=33.19; 39.12*5/9.43=20.74; 20.74*33.19=688 cm2= 0.0688 m2.) Same for LCD but actual viewing surface. 1000*0.0688 inserted in the EcoReport!

9. 15" LCD with 4/3 relationship between sides (1024*768)[47] corresponds to 697 cm2 nominal surface (15*2.54=38.1; $(4^2+3^2)^{1/2}$=5; 38.1*4/5=30.48; 38.1*3/5=22.86; 30.48*22.86=697 cm2= 0.0697 m2.) 1000*0.0697 inserted in the EcoReport!

10. 17" CRT with 4/3 relationship between sides (1024*768)[48] corresponds to 894 cm2 nominal surface (17*2.54=43.18; $(4^2+3^2)^{1/2}$=5; 43.18*4/5=34.54; 43.12*3/5=25.87; 34.54*25.87=894 cm2= 0.0894 m2.)

11. The materials in the LCD screen subassemblies are allocated according to below following an Environmental Product Declaration of LCD screens made by LG Electronics, see www.environdec.com.

LCD allocation	Weight %
Steel	49,5
Copper	0,4
Eps	10,7
PMMA	7,7
LDPE (PET+PE+Other)	8,3
PC	6,5
Glass	15,6
PWB 6 lay 4.5 kg/m2	0,25

[45] 1024*768 corresponds to sides 4/3

[46] 1024*768 corresponds to sides 4/3

[47] 1024*768 corresponds to sides 4/3

[48] 1024*768 corresponds to sides 4/3

Slots / ext. ports	0,40
IC's avg. 5% Si, Au	0,10
IC's avg., 1% Si	0,10
SMD&LEDs avg	0,13
Solder	0,02

Where the glass is booked as Misc material without subcategory in the Ecoreport.

12. Unspecified filled plastics in LCD assumed to be equivalent to PC with 30% glass fibre

13. Components containing refractory ceramic fibers assumed to be equivalent to *aramid fibre* (which is believed to be carcinogenic)

14. Unspecified batteries assumed to be equivalent to *big caps & coils*

15. Printed circuit assemblies >10 cm2 in desktops and displys (except for power supply) assumed to be equivalent to:

Electronics	**%**
PWB 6 lay 4.5 kg/m2	25
Slots / ext. ports	30
Big caps & coils	10
IC's avg. 5% Si, Au	10
IC's avg., 1% Si	10
SMD&LEDs avg	13
Solder	2

16. Printed circuit assemblies >10 cm2 in laptops (except for power supply) assumed to be equivalent to:

Electronics	**%**
PWB 6 lay 4.5 kg/m2	25
Slots / ext. ports	40
IC's avg. 5% Si, Au	10
IC's avg., 1% Si	10
SMD&LEDs avg	13
Solder	2

17. Printed circuit assemblies >10 cm2 in computers for power supply assumed to be equivalent to:

Electronics	**%**
PWB 1/2 lay 3.75 kg/m2	10
Big caps & coils	65
IC's avg., 1% Si	5
SMD&LEDs avg	15
Solder	5
Sum	100

18. PET assumed to be equivalent to LDPE (because similar Ecoindicator 99 value in IVF database)

19. Mylar assumed to be equivalent to LDPE (because it is based on PET)

20. POM assumed to be equivalent to LDPE (because similar Ecoindicator 99 value in IVF database)

21. Ni assumed to be equivalent to Cu wire (because similar Ecoindicator 99 value in IVF database)

22. Switch assumed to be equivalent to 50% *slots and external ports* and 50% *ICs SMD*

23. Batteries assumed to be equivalent to *big caps and coils* (because there was no better alternative. Lot 7 made the same assumption). An important improvement suggestion for the EcoReport is better modelling capabilities for batteries!

11 Appendix 2: Environmental impacts during the production phase

Nr: 0	Product:	EuP Lot 3 prep study: Office desktop PC	Date:	00-01-00	Author:	MZ

MATERIALS EXTRACTION & PRODUCTION

nr	Product component	wght	cat.	material	Energy GER	Energy electr	Energy feedst	Water water (proces	Water water (cool)	Waste haz. Waste	Waste non-haz. Waste	Emissions to Air GWP	Emissions to Air AD	Emissions to Air VOC	Emissions to Air POP	Emissions to Air HM	Emissions to Air PAH	Emissions to Air PM	to Water Metal	to Water EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	mg	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
1	LDPE	246	1-BlkPlastics	1-LDPE	19,14	3,27	12,68	0,74	11,07	1,09	10,87	0,47	1,83	0,12	0,00	0,00	0,03	0,23	0,00	6,55
2	ABS	380,75	1-BlkPlastics	10-ABS	36,18	2,65	17,43	3,54	62,82	3,81	35,00	1,26	6,77	0,00	0,00	0,00	0,69	1,10	0,74	239,81
3	PA 6	137,68	2-TecPlastics	11-PA 6	16,45	2,08	5,36	2,20	30,15	2,62	24,27	1,18	5,38	0,00	0,00	0,00	0,06	0,74	6,75	257,78
4	PC	264,25	2-TecPlastics	12-PC	30,87	3,93	10,04	3,70	30,12	2,64	46,65	1,43	6,72	0,00	0,00	0,00	0,10	1,77	0,04	133,19
5	Epoxy	97,9	2-TecPlastics	14-Epoxy	13,78	2,40	4,17	1,86	37,59	1,86	39,80	0,65	4,30	0,00	0,00	0,00	0,01	1,47	0,00	944,72
6	Flex PUR	1,5	2-TecPlastics	16-Flex PUR	0,16	0,03	0,06	0,11	0,45	0,05	0,82	0,01	0,05	0,00	0,00	0,00	0,03	0,01	0,01	8,53
7	Steel sheet galvanized	6312,3	3-Ferro	21-St sheet galv.	214,62	14,38	0,47	0,00	0,00	0,00	10866,70	17,85	47,12	0,86	164,12	22,37	0,44	17,09	22,41	411,37
8	Steel tube/ profile	106,5	3-Ferro	22-St tube/profile	1,81	0,49	-0,02	0,00	0,00	0,00	85,27	0,15	0,38	0,01	1,28	0,28	0,00	0,11	0,17	4,08
9	Cast iron	482,5	3-Ferro	23-Cast iron	4,83	0,07	-0,03	0,63	1,77	0,00	152,16	0,51	1,56	0,06	2,90	0,96	0,01	6,76	0,44	12,66
10	Ferrite	0	3-Ferro	24-Ferrite	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
11	Stainless 18/8 coil	9,5	3-Ferro	25-Stainless 18/8 coil	0,59	0,09	0,04	0,72	0,08	0,00	9,50	0,06	0,53	0,00	0,07	1,41	0,00	0,08	0,82	22,12
12	Al sheet/ extrusion	314,53	4-Non-ferro	26-Al sheet/extrusion	60,59	0,00	0,00	0,00	0,00	0,00	1232,96	3,25	21,17	0,02	1,57	1,14	30,36	5,32	11,01	1,56
13	Al diecast	15	4-Non-ferro	27-Al diecast	0,83	0,00	0,00	0,00	0,00	0,00	11,25	0,05	0,23	0,00	0,50	0,01	0,27	0,06	0,10	0,02
14	Cu winding wire	257	4-Non-ferro	28-Cu winding wire	36,68	0,00	0,00	0,00	0,00	0,21	5150,28	1,89	78,09	0,01	1,02	14,53	1,42	0,78	1,66	40,66
15	Cu wire	333,5	4-Non-ferro	29-Cu wire	38,87	0,00	0,00	0,00	0,00	0,08	6674,00	2,07	97,42	0,00	1,25	18,36	1,79	0,95	31,38	51,53
16	Cu tube/sheet	66,5	4-Non-ferro	30-Cu tube/sheet	3,39	0,00	0,00	0,00	0,00	0,00	532,93	0,18	4,16	0,00	0,68	2,20	0,36	0,10	2,50	4,12
17	Powder coating	1,62	5-Coating	39-powder coating	0,58	0,10	0,07	0,03	0,62	0,03	0,80	0,03	0,10	0,00	0,00	0,00	0,00	0,02	0,00	15,64
18	Big caps & coils	482,5	6-Electronics	44-big caps & coils	184,93	0,00	0,00	16,72	26,54	9,46	289,76	10,46	68,43	0,06	1,04	3,70	98,74	17,18	35,81	3,44
19	Slots /ext. Ports	310	6-Electronics	45-slots / ext. ports	57,99	18,39	0,00	23,14	79,16	5,30	95,38	3,11	57,15	0,00	0,43	11,78	0,60	4,02	9,86	2005,62
20	Integrated Circuits, 5% Silicon, Au	69	6-Electronics	46-IC's avg., 5% Si, Au	380,14	369,73	0,00	346,17	0,00	17,38	357,52	29,22	192,33	4,68	3,37	30,81	1,01	5,03	258,06	1482,19
21	Integrated Circuits, 1% Silicon	95,5	6-Electronics	47-IC's avg., 1% Si	83,48	64,29	0,29	58,40	9,89	61,56	166,96	5,62	77,95	0,00	0,94	17,67	0,28	2,31	0,92	410,30
22	SMD & LEDs avg	193,5	6-Electronics	48-SMD/ LED's avg.	574,47	558,36	0,00	179,07	0,00	25,29	547,78	32,32	313,56	1,45	2,90	81,60	0,88	9,83	2,85	424,83
23	PWB ½ lay 3.75 kg/m2	78	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	21,92	11,74	0,67	13,26	5,99	135,19	204,78	0,88	16,67	0,18	0,21	2,82	0,28	0,40	1,15	287,54
24	PWB 6 lay 4.5 kg/m2	162,5	6-Electronics	50-PWB 6 lay 4.5 kg/m2	59,67	23,75	1,39	78,82	12,48	307,42	661,91	2,55	64,35	0,17	0,83	11,38	1,12	6,02	20,38	396,95
25	Solder SnAg4Cu0.5	48	6-Electronics	52-Solder SnAg4Cu0.5	11,23	9,30	0,00	3,37	0,00	0,22	10,94	0,56	3,10	0,00	0,06	0,16	0,09	0,07	0,00	0,29
26	Cardboard	2286,5	7-Misc.	56-Cardboard	64,02	4,57	36,58	16,11	0,00	0,11	119,62	1,61	2,38	0,00	0,03	0,08	0,01	0,03	0,03	196,78
	TOTAL	0	0	0	1 917,20	1089,61	89,19	748,60	308,74	574,30	27327,92	117,33	1071,72	7,63	183,20	221,27	138,57	138,57	81,46	407,10

MANUFACTURING

nr	Product component	wght	cat.	NDX	Energy GER	Energy electr	Energy feedst	Water water proces	Water water (cool)	Waste haz.	Waste non-haz.	Emissions to Air GWP	Emissions to Air AD	Emissions to Air VOC	Emissions to Air POP	Emissions to Air HM	Emissions to Air PAH	Emissions to Air PM	to Water Metal	to Water EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	g	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
201	OEM Plastics Manufacturing (fixed)	1128,1	0	20	46,08	27,74	1,59	0,42	13,09	0,00	144,39	2,56	11,02	0,00	0,00	0,00	0,01	1,70	0,00	26,94
202	Foundries Fe/Cu/Zn (fixed)	482,5	0	34	1,06	0,64	0,04	0,01	0,30	0,00	3,32	0,06	0,25	0,00	0,00	0,00	0,00	0,04	0,00	0,62
203	Foundries Al/Mg (fixed)	15	0	35	0,10	0,06	0,00	0,00	0,03	0,00	0,31	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,06
204	Sheetmetal Manufacturing (fixed)	6702,8	0	36	101,41	61,05	3,49	0,92	28,80	0,00	317,76	5,63	24,26	0,01	0,00	0,00	0,00	3,74	0,00	40,01
205	PWB Manufacturing (fixed)	1343,5	0	53	172,62	4,31	6,41	15,83	48,04	5,67	143,47	11,45	65,83	4,17	0,13	1,18	3,47	20,20	0,57	952,83
206	Other materials (Manufacturing already in	3080,6	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
207	Sheetmetal Scrap (Please adjust percenta	1675,7	0,25	37	20,07	8,23	0,03	0,00	0,00	0,10	301,91	1,34	6,01	0,15	18,04	42,27	0,01	0,86	0,02	0,38
	TOTAL	12753			341,34	102,02	11,57	17,18	90,26	5,78	911,16	21,04	107,41	4,33	18,17	43,44	3,50	26,55	0,60	1020,84

Nr: 0 Product: EuP Lot 3 prep study: Laptops at home Date: 00-01-00 Author: MZ

MATERIALS EXTRACTION & PRODUCTION

nr	Product: component	wght (in g)	cat.	material	Energy: GER (MJ)	Energy: electr (MJ)	Energy: feedst (MJ)	Water: water (proces) (ltr.)	Water: water (cool) (ltr.)	Waste: haz. Waste (g)	Waste: non-haz. Waste (g)	Emissions to Air: GWP (kg CO2eq)	Emissions to Air: AD (g SO2eq)	Emissions to Air: VOC (mg)	Emissions to Air: POP (ng i-Teq)	Emissions to Air: HM (mg Ni eq)	Emissions to Air: PAH (mg Ni eq)	Emissions to Air: PM (g)	to Water: Metal (mg Hg/20eq)	to Water: EUP (mg PO4 eq)
1	LDPE	43	1-BlkPlastics	1-LDPE	3,35	0,57	2,22	0,13	1,94	0,19	1,90	0,08	0,32	0,02	0,00	0,00	0,01	0,04	0,00	1,14
2	PP	4	1-BlkPlastics	4-PP	0,29	0,03	0,21	0,02	0,16	0,02	0,11	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,66
3	PS	2,6667	1-BlkPlastics	5-PS	0,23	0,01	0,13	0,01	0,47	0,00	0,06	0,01	0,05	0,00	0,00	0,00	0,32	0,00	0,00	0,15
4	EPS	50,333	1-BlkPlastics	6-EPS	4,21	0,17	2,41	0,29	8,86	0,05	1,91	0,14	0,91	0,00	0,00	0,00	3,06	0,09	0,00	6,27
5	PVC	23,333	1-BlkPlastics	8-PVC	1,32	0,26	0,54	0,26	1,45	0,12	1,57	0,05	0,35	0,00	0,00	0,00	0,00	0,07	0,07	7,33
6	ABS	141,83	1-BlkPlastics	10-ABS	13,48	0,99	6,49	1,32	23,40	1,42	13,04	0,47	2,52	0,00	0,00	0,00	0,26	0,41	0,28	89,33
7	PA 6	280,54	2-TecPlastics	11-PA 6	33,53	4,24	10,92	4,49	61,44	5,33	49,45	2,40	10,95	0,00	0,00	0,00	0,11	1,51	13,75	525,25
8	PC	267,1	2-TecPlastics	12-PC	31,20	3,97	10,15	3,74	30,45	2,67	47,16	1,44	6,79	0,00	0,00	0,00	0,10	1,79	0,04	134,62
9	PMMA	36,333	2-TecPlastics	13-PMMA	4,00	0,48	1,52	0,36	0,94	0,05	3,81	0,22	1,58	0,00	0,00	0,00	0,00	0,19	0,10	75,14
10	Epoxy	2,6667	2-TecPlastics	14-Epoxy	0,38	0,07	0,11	0,05	1,02	0,05	1,08	0,02	0,12	0,00	0,00	0,00	0,00	0,04	0,00	25,73
11	Steel sheet galvanized	489,23	3-Ferro	21-St sheet galv.	16,63	1,11	0,04	0,00	0,00	0,00	842,22	1,38	3,65	0,07	12,72	1,73	0,03	1,32	1,74	31,88
12	Al sheet/ extrusion	37,9	4-Non-ferro	26-Al sheet/extrusion	7,30	0,00	0,00	0,00	0,00	0,00	148,57	0,39	2,55	0,00	0,19	0,14	3,66	0,64	1,33	0,19
13	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
14	Cu wire	60	4-Non-ferro	29-Cu wire	6,99	0,00	0,00	0,00	0,00	0,01	1200,72	0,37	17,53	0,00	0,22	3,30	0,32	0,17	5,65	9,27
15	Cu tube/sheet	15,2	4-Non-ferro	30-Cu tube/sheet	0,77	0,00	0,00	0,00	0,00	0,00	121,81	0,04	0,95	0,00	0,16	0,50	0,08	0,02	0,57	0,94
16	MgZn5 cast	121,67	4-Non-ferro	33-MgZn5 cast	19,69	0,00	0,00	14,42	1,59	0,68	582,30	2,24	5,48	0,01	3,33	0,32	5,93	1,11	2,18	0,44
17	Powder coating	4,7933	5-Coating	39-powder coating	1,71	0,29	0,20	0,09	1,84	0,10	2,36	0,09	0,30	0,00	0,00	0,01	0,00	0,07	0,00	46,27
18	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
19	0	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
20	LCD screen m2 (viewable screen size)	63,167	6-Electronics	42-LCD per m2 scrn	225,07	143,39	0,00	2,84	42,32	0,06	3,28	11,64	3,74	0,03	0,02	0,05	0,01	0,04	0,02	0,00
21	Big caps & coils	501	6-Electronics	44-big caps & coils	192,03	0,00	0,00	17,36	27,56	9,82	300,87	10,86	71,05	0,06	1,08	3,84	102,53	17,84	37,19	3,58
22	Slots /ext. Ports	132,93	6-Electronics	45-slots / ext. ports	24,87	7,88	0,00	9,92	33,95	2,27	40,90	1,33	24,51	0,00	0,19	5,05	0,26	1,72	4,23	860,04
23	Integrated Circuits, 5% Silicon, Au	46,833	6-Electronics	46-IC's avg., 5% Si, Au	258,02	250,95	0,00	234,96	0,00	11,79	242,66	19,83	130,54	3,17	2,29	20,91	0,69	3,41	175,16	1006,03
24	Integrated Circuits, 1% Silicon	31,167	6-Electronics	46-IC's avg., 5% Si, Au	171,71	167,00	0,00	156,36	0,00	7,85	161,49	13,20	86,87	2,11	1,52	13,92	0,46	2,27	116,56	669,49
25	SMD & LEDs avg	50,267	6-Electronics	47-IC's avg., 1% Si	43,94	33,84	0,15	30,74	5,21	32,40	87,88	2,96	41,03	0,00	0,49	9,30	0,15	1,21	0,48	215,96
26	PWB ½ lay 3.75 kg/m2	4,8	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	1,35	0,72	0,04	0,82	0,37	8,32	12,60	0,05	1,03	0,01	0,01	0,17	0,02	0,02	0,07	17,69
27	PWB 6 lay 4.5 kg/m2	76,867	6-Electronics	50-PWB 6 lay 4.5 kg/m2	28,22	11,24	0,66	37,28	5,90	145,42	313,10	1,21	30,44	0,08	0,39	5,39	0,53	2,85	9,64	187,77
28	Solder SnAg4Cu0.5	6,9667	6-Electronics	52-Solder SnAg4Cu0.5	1,63	1,35	0,00	0,49	0,00	0,03	1,59	0,08	0,45	0,00	0,01	0,02	0,01	0,01	0,00	0,04
29	Glass for lamps	0,6667	7-Misc.	54-Glass for lamps	0,01	0,01	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
30	Cardboard	921	7-Misc.	56-Cardboard	25,79	1,84	14,74	6,49	0,00	0,04	48,18	0,65	0,96	0,00	0,01	0,03	0,00	0,01	0,01	79,26
31	Glass for LCD	362,33	7-Misc.	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	0	0	0	1 117,72	630,41	50,51	522,45	248,86	228,70	4230,63	71,15	444,69	5,57	22,63	64,69	118,54	118,54	36,88	369,06

MANUFACTURING

nr	Product: component	wght (in g)	cat.	NDX	Energy: GER (MJ)	Energy: electr (MJ)	Energy: feedst (MJ)	Water: water proces (ltr.)	Water: water (cool) (ltr.)	Waste: haz. (g)	Waste: non-haz. (g)	Emissions to Air: GWP (kg CO2eq)	Emissions to Air: AD (g SO2eq)	Emissions to Air: VOC (g)	Emissions to Air: POP (ng i-Teq)	Emissions to Air: HM (mg Ni eq)	Emissions to Air: PAH (mg Ni eq)	Emissions to Air: PM (g)	to Water: Metal (mg Hg/20eq)	to Water: EUP (mg PO4 eq)
201	OEM Plastics Manufacturing (fixed)	851,81	0	20	34,80	20,95	1,20	0,32	9,88	0,00	109,03	1,93	8,32	0,00	0,00	0,00	0,01	1,28	0,00	20,34
202	Foundries Fe/Cu/Zn (fixed)	0	0	34	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
203	Foundries Al/Mg (fixed)	121,67	0	35	0,79	0,48	0,03	0,01	0,22	0,00	2,48	0,04	0,19	0,00	0,00	0,00	0,00	0,03	0,00	0,46
204	Sheetmetal Manufacturing (fixed)	542,33	0	36	8,21	4,94	0,28	0,07	2,33	0,00	25,71	0,46	1,96	0,00	0,00	0,00	0,00	0,30	0,00	3,24
205	PWB Manufacturing (fixed)	800,57	0	53	102,86	2,57	3,82	9,43	28,63	3,38	85,49	6,82	39,23	2,48	0,08	0,70	2,07	12,04	0,34	567,77
206	Other materials (Manufacturing already in	1462,2	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
207	Sheetmetal Scrap (Please adjust percenta	135,58	0,25	37	1,62	0,67	0,00	0,00	0,00	0,01	24,43	0,11	0,49	0,01	1,46	3,42	0,00	0,07	0,00	0,03
	TOTAL	3778,6			148,28	29,60	5,33	9,83	41,06	3,39	247,14	9,36	50,19	2,50	1,54	4,12	2,08	13,72	0,34	591,85

Nr: 0			Product:	EuP Lot 3 prep study: LCD display in office									Date:	00-01-00		Author:		MZ		

MATERIALS EXTRACTION & PRODUCTION

	Product				Energy			Water		Waste		Emissions to Air							to Water	
nr	component	wght	cat.	material	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	mg	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
1	LDPE	164	1-BlkPlastics	1-LDPE	12,76	2,18	8,45	0,49	7,38	0,73	7,25	0,31	1,22	0,08	0,00	0,00	0,02	0,15	0,00	4,37
2	EPS	278,7	1-BlkPlastics	6-EPS	23,32	0,94	13,32	1,59	49,05	0,26	10,55	0,75	5,05	0,00	0,00	0,00	16,96	0,50	0,00	34,73
3	PVC	42,8	1-BlkPlastics	8-PVC	2,42	0,48	0,98	0,47	2,65	0,21	2,87	0,09	0,64	0,00	0,00	0,00	0,00	0,12	0,12	13,44
4	ABS	679,1	1-BlkPlastics	10-ABS	64,53	4,72	31,08	6,32	112,05	6,79	62,43	2,25	12,07	0,00	0,00	0,00	1,23	1,97	1,32	427,73
5	PA 6	422,22	2-TecPlastics	11-PA 6	50,46	6,39	16,43	6,76	92,47	8,02	74,42	3,61	16,48	0,00	0,00	0,00	0,17	2,28	20,70	790,51
6	PC	384,75	2-TecPlastics	12-PC	44,94	5,72	14,62	5,39	43,86	3,85	67,93	2,07	9,78	0,00	0,00	0,00	0,14	2,58	0,06	193,92
7	PMMA	152,85	2-TecPlastics	13-PMMA	16,84	2,00	6,39	1,50	3,97	0,21	16,01	0,92	6,66	0,00	0,00	0,00	0,00	0,78	0,43	316,10
8	E-glass fibre	119,75	2-TecPlastics	18-E-glass fibre	7,88	2,53	1,29	6,50	32,49	0,84	37,27	0,40	3,49	0,00	0,00	0,00	0,01	0,98	5,67	377,38
9	Aramid fibre	6,5	2-TecPlastics	19-Aramid fibre	1,67	0,53	0,27	1,38	6,88	0,18	7,89	0,09	0,74	0,00	0,00	0,00	0,00	0,21	1,20	79,89
10	Steel sheet galvanized	1854	3-Ferro	21-St sheet galv.	63,04	4,22	0,14	0,00	0,00	0,00	3191,70	5,24	13,84	0,25	48,20	6,57	0,13	5,02	6,58	120,82
11	Al sheet/ extrusion	39	4-Non-ferro	26-Al sheet/extrusion	7,51	0,00	0,00	0,00	0,00	0,00	152,88	0,40	2,62	0,00	0,19	0,14	3,76	0,66	1,37	0,19
12	Cu wire	189,6	4-Non-ferro	29-Cu wire	22,10	0,00	0,00	0,00	0,00	0,05	3794,28	1,18	55,38	0,00	0,71	10,44	1,02	0,54	17,84	29,30
13	Powder coating	1,03	5-Coating	39-powder coating	0,37	0,06	0,04	0,02	0,40	0,02	0,51	0,02	0,06	0,00	0,00	0,00	0,00	0,02	0,00	9,94
14	LCD screen m2 (viewable screen size)	91,3	6-Electronics	42-LCD per m2 scrn	325,32	207,25	0,00	4,11	61,17	0,09	4,75	16,83	5,40	0,04	0,03	0,07	0,01	0,05	0,03	0,00
15	Big caps & coils	41,35	6-Electronics	44-big caps & coils	15,85	0,00	0,00	1,43	2,27	0,81	24,83	0,90	5,86	0,01	0,09	0,32	8,46	1,47	3,07	0,30
16	Slots /ext. Ports	36,55	6-Electronics	45-slots / ext. ports	6,84	2,17	0,00	2,73	9,33	0,62	11,25	0,37	6,74	0,00	0,05	1,39	0,07	0,47	1,16	236,47
17	Integrated Circuits, 5% Silicon, Au	12,85	6-Electronics	46-IC's avg., 5% Si, Au	70,79	68,86	0,00	64,47	0,00	3,24	66,58	5,44	35,82	0,87	0,63	5,74	0,19	0,94	48,06	276,03
18	Integrated Circuits, 1% Silicon	20,35	6-Electronics	47-IC's avg., 1% Si	17,79	13,70	0,06	12,44	2,11	13,12	35,58	1,20	16,61	0,00	0,20	3,76	0,06	0,49	0,20	87,43
19	SMD & LEDs avg	10,7	6-Electronics	48-SMD/ LED's avg.	31,77	30,88	0,00	9,90	0,00	1,40	30,29	1,79	17,34	0,08	0,16	4,51	0,05	0,54	0,16	23,49
20	PWB ½ lay 3.75 kg/m2	30	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	8,43	4,52	0,26	5,10	2,30	52,00	78,76	0,34	6,41	0,07	0,08	1,08	0,11	0,15	0,44	110,59
21	PWB 6 lay 4.5 kg/m2	19,6	6-Electronics	50-PWB 6 lay 4.5 kg/m2	7,20	2,86	0,17	9,51	1,51	37,08	79,84	0,31	7,76	0,02	0,10	1,37	0,13	0,73	2,46	47,88
22	Solder SnAg4Cu0.5	7,55	6-Electronics	52-Solder SnAg4Cu0.5	1,77	1,46	0,00	0,53	0,00	0,03	1,72	0,09	0,49	0,00	0,01	0,03	0,01	0,01	0,00	0,05
23	Glass for lamps	26	7-Misc.	54-Glass for lamps	0,42	0,34	0,00	0,22	0,00	0,01	0,35	0,02	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,01
24	Cardboard	650	7-Misc.	56-Cardboard	18,20	1,30	10,40	4,58	0,00	0,03	34,01	0,46	0,68	0,00	0,01	0,02	0,00	0,01	0,01	55,94
25	Office paper	54,5	7-Misc.	57-Office paper	2,18	0,33	1,47	4,15	0,00	0,02	3,68	0,03	0,27	0,01	0,00	0,01	0,00	0,09	0,00	288,22
26	Misc glass	307,6	7-Misc.	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
27	Cast iron	1165	3-Ferro	23-Cast iron	11,65	0,16	-0,07	1,51	4,26	0,00	367,39	1,23	3,77	0,14	6,99	2,31	0,02	16,31	1,06	30,56
	TOTAL	0	0	0	836,04	363,58	105,31	151,09	434,16	129,61	8165,00	46,34	235,29	1,58	57,46	37,77	32,56	32,56	37,07	111,93

MANUFACTURING

	Product				Energy			Water		Waste		Emissions to Air							to Water	
nr	component	wght	cat.	NDX	GER	electr	feedst	water proces	water (cool)	haz.	non-haz.	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO2eq	g SO2eq	g	ng i-Teq	mg Ni eq	mg Ni eq	g	mg Hg/20eq	mg PO4 eq
201	OEM Plastics Manufacturing (fixed)	2250,7	0	20	91,94	55,35	3,17	0,83	26,11	0,00	288,09	5,10	21,99	0,01	0,00	0,00	0,03	3,39	0,00	53,74
202	Foundries Fe/Cu/Zn (fixed)	1165	0	34	2,56	1,54	0,09	0,02	0,73	0,00	8,02	0,14	0,61	0,00	0,00	0,00	0,00	0,09	0,00	1,50
203	Foundries Al/Mg (fixed)	0	0	35	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
204	Sheetmetal Manufacturing (fixed)	1893	0	36	28,64	17,24	0,99	0,26	8,13	0,00	89,74	1,59	6,85	0,00	0,00	0,00	0,00	1,06	0,00	11,30
205	PWB Manufacturing (fixed)	158,6	0	53	20,38	0,51	0,76	1,87	5,67	0,67	16,94	1,35	7,77	0,49	0,02	0,14	0,41	2,38	0,07	112,48
206	Other materials (Manufacturing already in	1340,4	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
207	Sheetmetal Scrap (Please adjust percenta	473,25	0,25	37	5,67	2,32	0,01	0,00	0,00	0,03	85,26	0,38	1,70	0,04	5,10	11,94	0,00	0,24	0,01	0,11
	TOTAL	6807,7			149,18	76,96	5,01	2,98	40,64	0,70	488,04	8,56	38,93	0,54	5,11	12,08	0,44	7,17	0,07	179,13

Nr: 0	Product: EuP Lot 3 prep study: CRT 17"	Date: 00-01-00	Author: MZ

MATERIALS EXTRACTION & PRODUCTION

nr	Product component	wght in g	cat.	material	Energy GER MJ	Energy electr MJ	Energy feedst MJ	Water water (proces ltr.	Water water (cool) ltr.	Waste haz. Waste g	Waste non-haz. Waste g	Emissions to Air GWP kg CO2eq	Emissions to Air AD g SO2eq	Emissions to Air VOC mg	Emissions to Air POP ng i-Teq	Emissions to Air HM mg Ni eq	Emissions to Air PAH mg Ni eq	Emissions to Air PM g	to Water Metal mg Hg/20eq	to Water EUP mg PO4 eq
1	EPS	165	1-BlkPlastics	6-EPS	13,80	0,56	7,89	0,94	29,04	0,15	6,25	0,45	2,99	0,00	0,00	0,00	10,04	0,30	0,00	20,56
2	PVC	43,8	1-BlkPlastics	8-PVC	2,48	0,49	1,00	0,48	2,72	0,22	2,94	0,09	0,66	0,00	0,00	0,00	0,00	0,13	0,12	13,75
3	ABS	1754,8	1-BlkPlastics	10-ABS	166,74	12,20	80,31	16,32	289,53	17,55	161,31	5,83	31,18	0,00	0,00	0,00	3,17	5,09	3,40	1105,22
4	PA 6	447,47	2-TecPlastics	11-PA 6	53,48	6,77	17,41	7,16	98,00	8,50	78,88	3,83	17,47	0,00	0,00	0,00	0,18	2,42	21,93	837,79
5	PC	0,55	2-TecPlastics	12-PC	0,06	0,01	0,02	0,01	0,06	0,01	0,10	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,28
6	Steel sheet galvanized	126	3-Ferro	21-St sheet galv.	4,28	0,29	0,01	0,00	0,00	0,00	216,91	0,36	0,94	0,02	3,28	0,45	0,01	0,34	0,45	8,21
7	Al sheet/ extrusion	14	4-Non-ferro	26-Al sheet/extrusion	2,70	0,00	0,00	0,00	0,00	0,00	54,88	0,14	0,94	0,00	0,07	0,05	1,35	0,24	0,49	0,07
8	Cu wire	222,2	4-Non-ferro	29-Cu wire	25,90	0,00	0,00	0,00	0,00	0,05	4446,67	1,38	64,91	0,00	0,83	12,23	1,20	0,63	20,91	34,33
9	Powder coating	6,03	5-Coating	39-powder coating	2,15	0,37	0,26	0,11	2,32	0,12	2,97	0,11	0,38	0,00	0,00	0,01	0,00	0,09	0,00	58,20
10	CRT screen m2 (nominal screen size)	90,2	6-Electronics	43-CRT per m2 scrn	285,84	192,22	0,00	26,18	0,00	4,42	222,61	15,42	97,15	72,25	1,26	84,16	0,00	254,63	1,26	56,80
11	Big caps & coils	37,5	6-Electronics	44-big caps & coils	14,37	0,00	0,00	1,30	2,06	0,74	22,52	0,81	5,32	0,00	0,08	0,29	7,67	1,34	2,78	0,27
12	Slots /ext. Ports	40	6-Electronics	45-slots / ext. ports	7,48	2,37	0,00	2,99	10,21	0,68	12,31	0,40	7,37	0,00	0,06	1,52	0,08	0,52	1,27	258,79
13	Integrated Circuits, 5% Silicon, Au	17	6-Electronics	46-IC's avg., 5% Si, Au	93,66	91,09	0,00	85,29	0,00	4,28	88,08	7,20	47,38	1,15	0,83	7,59	0,25	1,24	63,58	365,18
14	Integrated Circuits, 1% Silicon	13,5	6-Electronics	47-IC's avg., 1% Si	11,80	9,09	0,04	8,25	1,40	8,70	23,60	0,79	11,02	0,00	0,13	2,50	0,04	0,33	0,13	58,00
15	SMD & LEDs avg	12,5	6-Electronics	48-SMD/ LED's avg.	37,11	36,07	0,00	11,57	0,00	1,63	35,39	2,09	20,26	0,09	0,19	5,27	0,06	0,64	0,18	27,44
16	PWB ½ lay 3.75 kg/m2	96	6-Electronics	49-PWB 1/2 lay 3.75kg/m2	26,98	14,45	0,82	16,32	7,37	166,39	252,03	1,08	20,52	0,22	0,26	3,47	0,34	0,49	1,42	353,90
17	PWB 6 lay 4.5 kg/m2	23,5	6-Electronics	50-PWB 6 lay 4.5 kg/m2	8,63	3,43	0,20	11,40	1,80	44,46	95,72	0,37	9,31	0,02	0,12	1,65	0,16	0,87	2,95	57,40
18	Solder SnAg4Cu0.5	11	6-Electronics	52-Solder SnAg4Cu0.5	2,57	2,13	0,00	0,77	0,00	0,05	2,51	0,13	0,71	0,00	0,01	0,04	0,02	0,02	0,00	0,07
19	Glass for lamps	6,5	7-Misc.	54-Glass for lamps	0,11	0,08	0,00	0,06	0,00	0,00	0,09	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00
20	Cardboard	1880	7-Misc.	56-Cardboard	52,64	3,76	30,08	13,25	0,00	0,09	98,36	1,32	1,95	0,00	0,02	0,06	0,01	0,02	0,02	161,80
21	Office paper	280	7-Misc.	57-Office paper	11,20	1,68	7,56	21,32	0,00	0,09	18,91	0,16	1,41	0,06	0,01	0,03	0,00	0,46	0,01	1480,75
22	Misc glass	11110	7-Misc.	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	0	0	0	823,99	377,05	145,61	223,72	444,52	258,14	5843,02	41,96	341,90	73,83	7,16	119,31	24,58	24,58	269,78	120,92

MANUFACTURING

nr	Product component	wght in g	cat.	NDX	Energy GER MJ	Energy electr MJ	Energy feedst MJ	Water water proces ltr.	Water water (cool) ltr.	Waste haz. g	Waste non-haz. g	Emissions to Air GWP kg CO2eq	Emissions to Air AD g SO2eq	Emissions to Air VOC g	Emissions to Air POP ng i-Teq	Emissions to Air HM mg Ni eq	Emissions to Air PAH mg Ni eq	Emissions to Air PM g	to Water Metal mg Hg/20eq	to Water EUP mg PO4 eq
201	OEM Plastics Manufacturing (fixed)	2411,6	0	20	98,51	59,31	3,39	0,89	27,97	0,00	308,68	5,47	23,57	0,01	0,00	0,00	0,03	3,63	0,00	57,59
202	Foundries Fe/Cu/Zn (fixed)	0	0	34	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
203	Foundries Al/Mg (fixed)	0	0	35	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
204	Sheetmetal Manufacturing (fixed)	140	0	36	2,12	1,28	0,07	0,02	0,60	0,00	6,64	0,12	0,51	0,00	0,00	0,00	0,00	0,08	0,00	0,84
205	PWB Manufacturing (fixed)	237,5	0	53	30,52	0,76	1,13	2,80	8,49	1,00	25,36	2,02	11,64	0,74	0,02	0,21	0,61	3,57	0,10	168,44
206	Other materials (Manufacturing already in	13608	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
207	Sheetmetal Scrap (Please adjust percenta	35	0,25	37	0,42	0,17	0,00	0,00	0,00	0,00	6,31	0,03	0,13	0,00	0,38	0,88	0,00	0,02	0,00	0,01
	TOTAL	16397			131,57	61,51	4,60	3,71	37,07	1,01	346,99	7,64	35,84	0,75	0,40	1,09	0,64	7,30	0,10	226,87

12 Appendix 3: Joint Industry Ecodesign Requirements Options for PCs and Monitors (Lot3)

Brussels, March 20th 2007

Joint Position Paper: Ecodesign Requirements Options for EuP Study on PCs and Monitors (Lot 3)

For many years the electronics industry has been committed to putting on the market environmentally conscious designed products as part of their sustainability policy. The electronics industry believes that environmental regulation, if necessary, should favour a level playing field and support industry moves towards continuously improved products. EICTA, AeA Europe and JBCE have welcomed the EuP ecodesign framework Directive as an opportunity for our industry to see further stimulation of our already comprehensive ecodesign efforts.

The electronics industry supports voluntary, market oriented programs and initiatives, including industryled standards, such as Energy Star, which highlight and sustain energy efficient product design and purchasing.

However, voluntary initiatives may contain aspirational elements and should not be used to regulate products. Legal requirements should complement and build on existing voluntary efforts to the maximum degree possible.

Legal requirements are most effective as an instrument to protect public health and the environment and to establish a minimum acceptable performance level while voluntary programs should provide direction to those seeking to go beyond baseline performance levels.

In the case the European Commission decides to propose legislation for PCs and monitors through an implementing measure of the EuP ecodesign framework Directive, EICTA, AeA Europe and JBCE would be in favour of the adoption of ecodesign requirements options similar to the ones specified below. We believe that these options will enable the European Union to meet the goals of the EuP ecodesign framework Directive while simultaneously driving measurable innovation within the IT industry at a manageable cost.

It is important however to take into account that these ecodesign requirement options are very much dependent on the actual implementation date of the EuP implementing measure. The IT industry has fixed redesign cycles and would need at least 12 months from adaptation to implementation of an EuP implementing measure. If this transition timeframe is prolonged, EICTA, AeA Europe and JBCE are of the opinion that ecodesign requirement options similar to the existing voluntary programs, such as Energy Star, could be envisaged.

Feature	Product Category	Ecodesign requirements options (allowing for one product re-design cycle)	Ecodesign requirement options with prolonged transition time (e.g. 4+ years out)	Test procedure
Internal Power Supplier/IPS	Desktops	• 70% efficient at 20% load • 75% efficient at 50% and full load	• 80% efficiency levels (tested at 20%, 50%, and 100% loading)s • 0.9PF (Power Factor) at 100% load	http://www.efficientpowersupplies.org/
External Power Supplies (EPS)	Desktops, Notebooks	Must correspond with recommended improvement options for EuP Lot 7: • ≥84% efficiency (tested at 100%, 75%, 50%, and 25% of rated current output) • No load: 0.75 W (Harmonized with California CEC, E* Tier II for EPS)	n.a.	http://www.energystar.gov/ia/partners/prod_development/downloads/power_supplies/EPSupplyEffic_TestMethod_0804.pdf
Sleep	Desktops, Notebooks	Sleep (S3): • 10 W • Shipped w/ power management enabled • Computers enter low-power state after 30 minutes of inactivity	Sleep (S3): • 4 W/ 4.7 W (for desktops) • 1 W/ 1.7 W (for notebooks) (Harmonized with E* 4.0 Tier 1 for PCs)	http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Computer_Spec_Final.pdf
Off / Standby	Desktops, Notebooks	Off/standby (S4/S5): • 5 W	Off/standby (S4/S5): • 2 W / 2.7 W (for desktops) • 1.7 W / 2.4 W (for notebooks) (Harmonized with E* 4.0 Tier 1 for PCs)	http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Computer_Spec_Final.pdf
Display Energy	Displays (only LCD smaller 30")	• Maximum active power consumption equation: Y = 38X + 30. (Y is expressed in watts and rounded up to the nearest whole number and X is the number of mega pixels in decimal form) • Sleep Mode ≤4 W • Off Mode ≤2 W • Shipped w/ power management enabled • Displays enter sleep mode after 15 minutes of inactivity (Harmonized with E* 4.1 Tier 1 (covers on, sleep, and off mode))	n.a.	http://www.energystar.gov/ia/partners/product_specs/program_reqs/MonitorSpecV4.1.pdf
User Education	Desktops, Notebooks	Include with each computer information on the benefits of power management in either a hard copy or electronic copy of the user manual. At least the following information must be include: • Notice that the computer has been shipped enabled for power management and what the time settings are • How to properly wake the computer from Sleep mode (Harmonized with E* 4.0 for PCs)	n.a.	

Joint Industry Ecodesign Requirements Options for PCs and Monitors (20th March 2007)

Note that the sleep and off/standby figures for laptops have been mixed and shall be the other way around.

AeA Europe

AeA Europe represents leading European high-tech operations with American parentage. Collectively we invest Euro 100 bn in Europe and employ approximately 500,000 Europeans. Member companies are active throughout the high-technology spectrum, from software, semiconductors and computers to Internet technology, advanced electronics and telecommunications systems and services. Our parent company, AeA, is the oldest and largest US high-tech association (2500 + companies).

EICTA

EICTA, founded in 1999 is the voice of the European digital technology industry, which includes large and small companies in the Information and Communications Technology and Consumer Electronics Industry sectors. It is composed of 55 major multinational companies and 38 national associations from 27 European countries. In all, EICTA represents more than 10,000 companies all over Europe with more than 2 million employees and over EUR 1,000 billion in revenues.

JBCE

The Japan Business Council in Europe was founded in 1999 as the representative organisation for Japanese companies operating in the European Union. Our members consists more than 60 leading multinational corporations for electric, electronic, automobile and chemical sectors in the world. The JBCE's key objective is to contribute to EU public policy issues in a positive way, drawing upon the experience gained in Japan and other countries and utilizing the expertise developed in specific fields, such as environmental protection and technological innovation.

Appendix 4: Stakeholder feedback on task reports Eup preparatory study Lot 3

Task	Comment	Action
0	We are putting on the EU market LCD monitors with which screen size are over 30". As you probably know, Energy Star is not categorized screen size but resolution. For instance, for SXGA (1280x1024) 28X1.31=37W is ON-mode power consumption limit regardless screen size. However, it is impossible to comply with this limitation for large screen size LCD. For example, our 32" LCD monitor has 1368x768(1.05 Mega pixel) and its rating power consumption is 120-140W. Energy Star limitation for 1.05 Mega pixel monitor is only 29.4W. This is the same kind of situation for other manufacturers. So, it is not practical to apply Energy Star standard for large screen size LCD monitors. Please take into account this issue in your Task report.	Done in the final report
0	We agrees with you in assuming that the PC is mostly in an idle state when the power is ON and that the rate of the ON/Sleep/Off state is as defined in task3. However, this can not explain the 50% margin of the power consumption. For example, on a 15" panel laptop PC, power consumption in high load state is triple that of when in the idle state.	Discussed at the workshop
0	As Lot3 will stipulate a mandatory standard, we would like to suggest that the focus be placed on the reduction of power consumption while the system is in "idle", "sleep" and "off"; no process is up and running. It is necessary for idle mode to investigate an adequate categorization of the product type or a ratio with function (factor-X).	Discussed at the workshop
0	We are afraid that it is not enough to categorize the computer into home and office, because idle power consumption of the high power desktop-replacement laptop PC is 10W bigger than one of low power mobile PC.	Discussed at the workshop
0	We would like to suggest that panel off condition should be requirement for idle mode in order to avoid disadvantage of larger power consumption by offering "large panel size", "high resolution" and "high brightness".	Noted
0	We would like to suggest that a terminological definition and a measuring method should be based on ENERGY STAR V4.0 as much as possible to avoid a double standard.	Very general comment, no action
1 Page 14, 15	Can you please add a definition / description for the "1 computer"	Done, since the calculations are made for products (desktop and laptop computer respectively) based on the definitions described in task 1.

Task	Comment	Action
1	P. 16: Display screen should not be included in the definition of the computer.	Accepted and done
1	P. 17: Product group performance and functional unit: A definition for computers could be based on the coverage of the user needs. One main group of user needs is e-mailing, web browsing and text process-ing, which could be characterized as “Office productivity”. Other, smaller groups are: Media centre com-puting; graphic processing, DTP etc.; and advanced computer calculations. This will be more refined than the definition “1 computer”. Electricity consumption of monitors is based both on amount of pixels and on screen size and the proposed definition is therefore relevant.	Agree, but could until now not find the measurement method. Waiting for ECMA, and until then use one computer. (When calculating the impact over Europe, one computer can be multiplied with the installed base. It is difficult to tell how many e-mails is needed within Europe)
1	P. 37: The ECMA working group is intending to reach a measurement method for the active mode of computers, which takes the performance into consideration. The work can used by US EPA and the Euro-pean Commission, when establishing Tier II for computers.	OK
1	P. 41: It should be mentioned that Danish governmental institutions are obliged to purchase energy effi-cient appliances due to “Circular on improving energy efficiency in Danish state institutions” from April 2005 (download it at www.elsparefonden.dk/publikationer/publications-in-english/circular-on-improving-energy-effiency). The energy efficiency criteria are the Danish Electricity Saving Trust’s pur-chasing guidelines, which for computers and monitors from 2007 correspond to Energy Star. From 1 January 2007, the Danish government’s Ministry of Finance centralised the government purchasing of se-lected product groups by selecting the specific products and entering framework contracts for a number of product groups including computers and monitors. These products should comply with purchasing guidelines.	Accepted and done
1	We support the proposed product definitions given in task report 1as they are based to a large extent on the existing product definitions given in Energy Star. We specifically welcome that workstations, desktop-dervied servers, game consoles, thin clients, handhelds and PDAs are not considered as part of the product group personal computers	OK
1	We also support the functional unit as one computer. Other functional units, such as “Euros of computer” or “computer years” seem not to be appropriate	OK
1	We also support the definition and the functional units for monitors, again as they are both based on current Energy Star definitions	OK
1	We support that Energy Star is quoted as the most important voluntary agreement for computers and monitors	OK

Task	Comment	Action
1	We are concerned however, that items such as electrical safety, EMC and noise are found in this section. And that focus is on energy (which is the main issue) and on noise.	To follow the instructions in the VHK and from the Commission regarding noise, we find it necessary to include them.
1	We also caution the use of the Japanese Top Runner system.	We have only described the Top runner system in order to fulfil the VHK methodology and describe available voluntary agreements.
1	We also would urge caution when quoting TCO as one of the most important voluntary agreement for monitros. Therefore a differentiation should be made with regards to PC and displays, whereas TCO is not important for PC but important for computer displays.	Accepted and done
1	I think it's a good idea to refer to Energy Star Computer Test Method (Version 4) for categorisations. But there are no measured values available for PC's based on this new standard!	Accepted
1	A lot of small language changes, such as wrong spellings etc.	Accepted and done
1	I think that there is a misunderstanding when you mention that "it will be relatively easy for industry to supply the LCA data needed thanks to WEEE". What we can deliver are data based on our eco-declarations which are already available (example attached).	Accepted. We have tried to get as good data as possible, and used the best we could get.
1.	What is the definition for "Type II" and "Type III"	Done. Described at the beginning of the chapter Voluntary agreements”
1	Many products are registered not at the European but at the international Energy Star program website, having even more products registered.	OK
1	Please note that the Japanese Top Runner System was argued by IT industry to be not applicable to the EuP (mainly because the EuP Directive prohibits market access to non-compliant models, while Japanese Top Runner does not).	We have only described the Top runner system in order to fulfil the VHK and describe available voluntary agreements.

Task	Comment	Action
1	We believe that this chapter should be revised since the ECMA-370 standard is already available since June 2006 (harmonization efforts are mentioned on page 34 but are now history since the standard is finalized) -> any criteria summary should be made based on ECMA-370 (common base for IT eco-declaration and ECMA based company declarations) -> only main difference is that IT eco-declarations are registered and underlie an external random quality check procedure organized by IT-företagen	Accepted and done
1	We believe that although TCO is listed as an important labelling scheme, it's not commonly adopted by PC manufacturers and therefore a differentiation should be made with regards to PCs and displays ("not important for PC" but "important for computer displays") In addition an eco-label such as TCO should not serve as the base line for a legal measure since it typically is a quality mark which should (according to self definition of the labels) only be met by 20% of the products placed on the market.	Accepted and Done
2	P. 10: IDC data and similar data are generally reliable and could be a better basis to use compared to the statistical data. You might get summary data for free from IDC due to the public benefit purpose. Furthermore, costs of purchasing the data should not be a barrier, if the data can improve the quality of the study. Regarding the installed base, there might be national surveys with valuable data. E. g. in Denmark we use the "Elmodel bolig" (model for electricity consumption in the residential sector, where part of the data comes from home surveys. Contact person for "Elmodel bolig":	Followed the methodology using EUROSTAT as the main source, combined with manufacturer information (which in many cases was similar to IDC-data)
2	P. 69: It is not clear what the section on consumer tests should provide of information, especially when mentioning specific products. There are many tests in many computer magazines, which could be in-cluded, one of the better is the German c't. This section should be re-thought and re-written. The advantages of laptops have not been included. There are many, in addition to the much lower power consumption.	No, we followed the methodology, and provided an anecdote we find of interest.
2	P. 71: Production structure: This section is very brief. One main point lacking is who is taking the design decisions and what is the basis for the decisions.	Agree,but not a part of this study

Task	Comment	Action
2	P. 72: Prospect 2010: We believe that this section should focus on market and features and not on tech-nology. The section is not complete. We believe that the following trends will be observed: • More transition to notebooks • Increased transition to thin clients, both in offices and homes • More computers in homes and offices • More computing and graphic display power and more storage • More use of internet based services (e-mail, text processing, storage) • More mobile and internet connected units with longer battery time • Faster startup and shut down by use of flash disks and sleep in stead of shut down • More desire to have units always on or at least always available • More merging of IT products and consumer electronics • More mobile high speed network connections • Larger displays • Convergence between products for home office and for entertainment.	We have based 2010 on the answers from the stakeholder survey, while we have used more independent sources for 2020. For several of the points covered in your comment, the stakeholders were not convinced on a breaktrhrough already 2010. Otherwise we agree with you on the general direction of development.
2	P. 73: Prospect 2020: This section seems to be based on near term trends extrapolated. The changes are difficult to predict and could be very different from the ones presented. E.g. regarding replacement of TV, DVD and CD by computers: The development will most like be a convergence, which already has started, so the appliances may be the same kind, but with different main functionalities. Some of themes discussed in this chapter focus on technology rather than market and features. Whether telephone conversations is IP based, traditional phone system based or mobile phone based is not important for the chapter. More important is to discuss whether other means of communication e.g. instant messaging and e-mailing will take over	Some of the features you find not important, will influence the usage patterns towards computers always on
2	We support the proposed average economic lifetimes.	OK
2	We do not se an added value of quoting Stifting Warentest or Tom´s Hardware Guide in this report	It is a part of the VHK and therefore included.
2	We support the data gathered on the market share of "Whiteboxes" and the conclusion drawn that these manufacturers are hard to reach for coluntary agreements. Additionally we believe that any enforcement of EuP Implementing Measures needs to take this into account as these white box manufacturers might decided to act as free riders. We also believe s that white boxes are mainly an issue for desktops, but also on a lesser scale for laptops.	OK
2	We does not follow the reasoning and the conclusions drawn on the repair of computers. Stating that every computer needs one repair at the cost of 125€during its useful life seems to be not realistic. Although computers sometimes need repair we believe that the reliability is much higher and the assumption is overly pessimistic	We stick to the 125 € and clarified that it is not only cost for repair, but a cost to cover also for upgrading and maintenance.

Task	Comment	Action
3	Clear definitions of modes is required at the very start of this document, and mention of modes in different studies will need to be equated to these definitions. For example, a "standby" mode is mentioned in a range of different studies/sections. In one study it refers to on-idle, and in the other to a type of off mode, whilst in another to a type of sleep mode. When "active" is referred to, it needs to be made very clear that this includes the on-idle component i.e. when the computer is switched on, the user is not actively using it, but the computer has not gone to sleep. Soft off and hard off should be defined at the very start too.	Definitions made in task 1.
3	A lot of language changes, such as wrong spellings, clarifications etc.	The final report has been reworked, concerning language and spelling.
3	Page 5 - "If sustainability is to be achieved, an optimal usage pattern should be automatically enforced" - this appears to be a policy recommendation. I understood the EuP preparatory studies would not be making policy recommendations?	OK
3	Page 8 - references to "AEA" - Please refer to this report as an "MTP" not "AEA" report. Please do refer to the "MTP method" rather than AEA. Also, you refer to the EST as the "Energy SavingS Trust" rather than "Energy Saving Trust". Page 9 - Table 2 heading - please refer to MTP not AEA.	Accepted and done
3	Page 15 - It is very difficult to take an average of all the studies mentioned in the EuP report since results vary so widely. This suggests that the final figures may not represent what happens in practise. During MTP investigations it was found that the use of mean figures resulted in use-profiles which were improbable. For this reason it was often necessary to make assumptions so that the use-profiles of the different products were believable. The use of mean figures in the EuP study has meant that some of the published use-profiles are also unlikely. Page 16 - Table 4 – comments on the usage pattern.	Discussed at the workshop.
3	P. 85 ff: It seems that “active” is used for both “active work on the computer” and “on idle”, but the differ-ence is important. In figure 4, p. 98, “active” is supposed to be “on idle”.	Clarified in the report
3	P. 85 ff: The data basis does not seem sufficiently elaborated. E.g., there are studies that show that many computers are on 24/7, even though they are not used 24/7. Check these references: http://enduse.lbl.gov/info/Pubs03_04.html (Roberson report) and http://enduse.lbl.gov/info/Pubs00_02.html (2001 Webber report).	Discussed at the workshop
3	P. 85 ff: Reasons to maintain the computer and monitor on is not well analysed or described. In general, computers and monitors are on much more time than needed. Therefore, there is a need to have the technology securing reduction of power consumption during un-used periods. This is an important factor of the power consumption of the computer and consequently of the electricity consumption and costs.	Agree, clarified in the report

Task	Comment	Action
4	Use of GHz to Describe PCs in Section 4, pg. 115 Characterization of desktop PCs by "3 GHz processor (or equivalent)" and mobile PCs by "1,7 GHz processor (or equivalent)" does not describe the performance characteristics of the PC. Would it be possible to describe the PC performance and provide the GHz as an example, for example: "high-performance desktop PC, e.g. 3 GHz (or equivalent)?	Accepted, done in the final version
4	Description of idle mode on pg. 125 Current text says "*In this study it is assumed that most of the time a computer is on, it is in idle mode. Of course this is not true, thus we know we have an error source.*" We believe that the computer spends a significant amount of time in idle mode, especially if sleep mode is not activated on a PC. We base this conclusion on some available studies.	Discussed at the workshop
4	Page 115 – Comments that "the manufacturers could not deliver data modularised the "EPIC" way" Could you provide details as to why this was not possible?	Done
4	Page 116 – Just because the average weight is similar, does not mean that it can be assumed that domestic desktops have a BOM very similar to non domestic desktops. In fact, the difference in weights is 20%, which is certainly significant and should not be discounted. The specifications of the two devices will be very different – for example, a domestic PC will be much more likely to have higher specified components such as powerful graphics cards. This will impact the BOM. Therefore your assumption is in accurate and invalid.	Clarified in the final report Average home PCs are not more powerful than office PCs according to our industry sources
4	Page 116 – The fact that there are more than twice as many domestic desktops as home desktops is surprising (on MTP we predict non domestic at similar levels to domestic) – where did this data come from? Please provide a reference in the document.	Description and references in task 2. Comment difficult to understand! (There are twice as many home desktops compared to office desktops)
4	Page 116 – As your data is based on PCs from 2005, and the PC market moves so quickly, you should discuss this risk/sensitivity in the document, as when it is published it will already be 2 years out of date.	Following the methodology it is done in task 8
4	Page 117 – You need to discuss the results in Table 59. What do they tell us? How do they compare with previous studies.	This is done in other tasks

Task	Comment	Action
4	Page 117 – Again, you need to provide a reference for the installed base figure. The average weight varies by 16% - again, this is a statistically significant number, and cannot be ignored. You should be making observations at this point as to why the domestic devices are heavier than the non-domestic devices (again, there are domestic products in the top weight range far exceeding those in office applications too). There is no need to average the weight, as you analyse domestic and non-domestic devices separately anyway. This approach weakens your analysis and reduces confidence in your results.	Installed based described in task 2
4	Page 118 – You have recognised that the inclusion of the laptop power supply in the BOM is an overlap with the external power supply study, but you have not mentioned how your figures compare with theirs, and how both studies will manage this overlap. The explanation of why glass is entered without subcategory is not clear, and it is not explained what impact this has on the final results. How representative is a laptop with a 15 inch screen? – you need to justify the choice of a 15 inch screen with quantification of the percentage of stock which has this screen size.	Clarified
4	Page 120 – you need to specify where the installed base figure come from and how this data compares with data from other sources. The proliferation of displays in homes (as desktop PCs) is surprising in comparison to the non-domestic figures. Comment on this should be made to put the findings in perspective.	Described in task 2
4	Page 120 – It is unlikely that there are more home CRT displays than there are LCD displays. CRT displays have been phased out rapidly, to be replaced by LCD displays. Therefore these figures look wrong.	Described in task 2 (To be noted is that the installed base comprise of products sold the last 5-6 years, why CRT still have some importance)
4	Page 124 – It is surprising that LCD display packaging should be twice as big as packaging for a laptop. You should comment on this result, as well as providing a reference for the figures.	It is referred
4	Page 125 – Last paragraph – You write that you “assume most of the time a computer is on it is in idle” – where do you derive this assumption from? You then state that “Of course this is not true” – which leads one to question why you made an assumption that you thought was false in the first place. You do not explain why you have this conflict or what you have done to resolve it in your analysis. You have also not been sufficiently clear with terminology – when you say “on” do you mean switched on at the plug, switched on at the PC, or switched on in an active mode? The potential error you state is a massive 50%, highlighting major failures in the robustness of the assumptions / research. We trust this will be given appropriate attention in Task 8, although it would have been better if more informed assumptions had been made initially.	Clarified in the final report

<table>
<tr><th>Task</th><th>Comment</th><th>Action</th></tr>
<tr><td>4</td><td>Page 126 - Comparison of figures with those of MTP (2005):
- Monitors are in active mode not idle mode
- Off mode cannot be more than sleep mode, as is shown for desktop PCs so this error needs to be corrected.
- Desktop consumption in all modes is underestimated, and the distinction between non domestic and domestic desktop PCs has been lost in the EuP analysis.
- Laptop consumption may be underestimated on MTP as we have not accounted for screen consumption.</td><td>- We do not use the word idle for monitors.
- As described in the final report, the off mode can be more than sleep mode, (10 % of the energy star qualified products have that pattern)
- We do stick to our estimations, since they are close to averages found in other sources.
- Described and clarified in the final report</td></tr>
<tr><td>4</td><td>Page 128 – Use phase data in tables 70 and 71– MTP has already commented on this data (comments on task 3 report) and raised a number of concerns.
1. The lifetimes used <u>for all products </u>are unrealistic for in-use, though they may be time to disposal. This has not been accounted for and is a major inaccuracy in the calculations.
2. The time spent in sleep is vastly overestimated and power management enabling rates have not been accounted for. In the UK, rates of power management are very low, and therefore time spent in sleep will be very low for an average PC. You have currently accounted for more time spent in sleep than in idle mode, which cannot be correct in the current environment.
3. Why have you separated out domestic and non domestic PCs here, but continued to use averaged figures – i.e. identical for both? The data which was collected enabled an analysis using specific figures for domestic and non domestic, and to average these brings errors into the process, and reduces the usefulness of the findings</td><td>1 Discussed at the workshop, where the lifetimes used were verified by many persons.

2 The usage pattern used is an average of many sources, including MTP. The MTP findings is based on a small sample in a specific environment and</td></tr>
</table>

Task	Comment	Action
		one country and can not be used as the average for all users within Europe until that is verified. We agree that the usage pattern can be further studied to get a more accurate result. We have clarified usage pattern used in the final report. 3. Do not understand the comment. We have used the home and office figures separately
4	Page 131 – monitor usage figures – the use for these is clearly wrong, as they sleep less than desktop PCs, which does not make logical sense. This was highlighted previously, and has still not been considered.	Discussed at the workshop, with a verification that computer and monitor are often NOT turned off at the same time by the user
4	P. 126: The figures in table 68 do not seem to be fully correct, especially regarding: • Off consumption for desktops should not be higher than the sleep consumption. • Sleep consumption for laptops should not be higher than sleep for desktops. • Sleep for monitors is typically higher than off. • Idle for laptops seems high.	Discussed at the workshop, clarified in the final report
4	The assumption to approximate lithium ion batteries with “large caps and coils” is indded a very chaky ssumption. It is suggested that this data I s verified by looking at existing LCAs for Li Ion batteries. Our suggestion would be to study this in more detail also in a sensitivity analysis.	Done in the sensitivity analysis
4	The sleep wattage value for desktops is lower than the off wattage value. This needs to be explained.	Explained at the workshop and in the final report
4	We would recommend using the Energy Star values or the contractors´summer survey for sleep and off for desktops	Explained at the workshop and in the final report
4	The 2.2 W sleep value appears too low for the average desktop	Explained at the workshop and in the final report

Task	Comment	Action
4	The sleep wattage value for desktops is lower than the sleep value for desktops. This needs to be explained.	Explained at the workshop and in the final report
4	"White boxes" not included, the actual situation in Europe could be that the real fugures are on average higher than given in the report. It might be worthwhile to methodically estimate this in more detail so that the white box market is taken into account more systematically	Discussed at the workshop
4	For the use phase of course the times assumed for the PC and display to be in idle sleep or off mode are most important when determining the impacts. We suggest that the time assumptions are further studied in more detail in a sensitivity analysis.	Done in the sensitivity analysis.
4	One interesting issue is that the phases for displays are different from the phases used for the corresponding PCs. This could be better explained (maybe by inserting the referenced task 3 chapter in the appendix) Since displays often have separate power management settings than desktops, they may have different usage patterns, but it is not explained in detail how the distinction has been arrived to.	Task 3 is already a part of the report.
4 –5	Description of processor as the most essential component from energy per unit point of view, in Section 9.1.1 on pg. 201 (215) Both Intel and AMD testing shows that the processor is not the most essential component from an energy point of view during the active/idle state; the processor becomes an increasing source of power consumption for more energy intensive operations such as playing video games	Discussed at the workshop
5	Focus area found in task 5 "production phase of motherboard including processor.." Regarding energy usage in the manufacturing phase of ICs (semiconductors) and with that processors, we would like to comment that manufacturing processes are undergoing constant changes and that for example AMD's goal is to improve specific energy consumption during the manufacturing phase (see also AMD's Climate Protection Plan at www.amd.com/climate.) Also product composition data, which were used to create the values for IC manufacturing in the EcoReport tool are constantly subject to change. So the factors used in the eco report tool are not expected to be representative over time.	We agree. For now, we used the values in the Ecoreport tool, which we hope will be further developed following the manufacturing development if it shall be used in the future.
5	Pg 139 - You state " For the real-life situation, the usage pattern and electricity consumption during different usage modes are crucial" and yet you have some major errors in your assumptions and calculations.	We do not agree. Discussed at the workshop
5	Pg 139 – where did the value of 40km for repairs come from? No reference has been provided.	Reference inserted in the final report
5	Pg 140 – mention of a 1% error in the production phase due to MEEUP tool assumptions regarding repair. It has should be stated here how this error will be dealt with in analysis.	Done

Task	Comment	Action
5	Pg 141 – The environmental impact tables are not adequately discussed in this report. Observations should be made on the various elements in the table and how they interact – current discussion around tables is very poor. For example: - The use phase is clearly where the most energy is used up, but this does not mean that it can be assumed that it has the greatest environmental impact. This will depend upon how the various measured impacts are prioritised i.e. energy vs water vs waste vs emissions. - There is a category for waste in-use, which shows a considerable amount – what does this waste amount relate to? - It is not clear how transportation in production is accounted for. - All the diagrams contain mention “see note” but no note or explanation has been provided in the report. - As well as a discussion of the interaction between the various environmental impacts, this report should also address how the impacts vary between products – for example, how production waste for CRTs is twice that of LCDs. - Conclusions arrived at do not go through a discursive process – they seem to just align with what one could have guessed before the work was completed. More depth required.	Further explained in the final report
5	Pg 149 – Base Life cycle costs: As commented previously, product life is far too high. The terms in the Table (92) should be explained – for example, what do you mean by “present worth factor”? You mention in the Task 6/7 component of the report that consumption of PCs has been increasing year on year, and yet here you state that “there was no significant change in energy consumption of PCs and monitors between 2002 and 2005” – this is in direct conflict with later statements, and with MTP models, which predict and increase in consumption over time. Table 93: In this table, it is suggested that office PCs are more expensive and have a greater life cycle cost that domestic PCs. MTP analysis would suggest that the opposite is true, and therefore this result should be questioned in detail and carefully justified.	Discussed at the workshop. Present worth factor is the factor used to calculate the life cycle cost including costs coming later, used by economists, and in the VHK methodology. Discussed at the workshop
5	Pg 151, 152 – Rather than just pasting these charts in, here should be discursive and analytical observations around them so that conclusions can be drawn. Pg 153 – discussion of reasons for impacts of products sold in 2005 versus total stock impacts: “Annnual sales 2005 multiplied by product life implies more units than the stock in 2005” – this highlights that lifetime is too long and that there are some major issues with the accuracy of the results arising from poor analysis and assumptions.	Described in the final report Lifetime used is verified by many sources.

Task	Comment	Action
5	Pg 201 – data collection – Mention of data sets. It appears that these data sets have been used blindly. In addition, no detail has been provided of the market coverage and number of products within these data sets.	Described in task 4 and appendix
5	Pg 203 on – it is not clear how data on production materials waste was gathered – it doesn't appear to be a section of the questionnaire, so how was this determined?	Used the Ecoreport tool as described in the VHK methodology
5	P. 150 ff: Due to the uncertainties on the involved parameters, the EU totals may not be correct.	Handled in the sensitivity analysis, task 8
5	The impacts of distribution in relation to the impacts of production seem to be on the high side. Depending on the base case distribution is between 10% (Laptop) to 20% (LCD) of the impact of production. Although all distribution processes have been taken into account (as we understand) the environmental impact seems to be rather high. This would mandate some more detailed study of explanation. It could also very well be that the MEEuP method has some flaws in this respect	We have used the Ecoreport, giving this results. Discussed at the workshop.
5	The impacts of production for LCD and CRT are of the same order of magnitude (e.g. 985 MJ to 9956 MJ for total energy). This is an interesting result, given that the manufacturing processes are so different	MEEup
5	For the EU totals it could be additionally take into account, that in office environments people need an additional monitor and a keyboard as add on for a laptop due to ergonomics requirements. In an energy perspective the impacts of an LCD could be added to Office Laptop for office workplaces.	Done, since the market figures include the extra LCD screens.
5	The definition of GER should be added in table 84 etc: GER stands for Gross Energy Requirement. Electricity from the public grid needs 10,5 MJ GER per kWh electricity	Accepted and done
6	Pg 168 "A typical PC with a power consumption of 100W in idle mode can reduce that by 20% using an "80-plus" power supply" – for this 100W PC, what initial efficiency are you assuming? To state that an 80-plus power supply has a standby consumption of less than 3W still sounds on the high side, considering Energy Star specification requires 2W in standby. More explanation of why flash drives are faster than hard disk is required, as well as an indication of the kinds of capacities that can be achieved with flash drives, and a more in depth understanding of how these might come to market as a replacement for hard disk drives. Reduced energy consumption of 7W is stated – this is a very precise figure, with no source. Please state source and use a qualifying statement such as "up to 7W".	Clarified in the final report

Task	Comment	Action
6	Description of processor as the most essential component from energy per unit point of view: (see Section 6.3 on pg. 165; section 7.1.2 – 7.1.3 page 178-180, which affects quantification of possible savings; as well as Appendix 1 Section 9.1.1 page 205) Pg 165: It is assumed that "For a desktop PC the processor will use approximately 40% of the supplied power,…" P 178: "The processor in a 2005 desktop computer takes roughly 40% of the energy,.." Both Intel and AMD testing shows that the processor is not the most essential component from an energy point of view during the active/idle state; the processor becomes an increasing source of power consumption for more energy intensive operations such as playing video games. We would like to point to our comments on the Task 4 and 5 Report (see below) where we provided some material that show that processor power utilization is less than 40% of PC total power. This of course affects projected savings in sections 7.1.2 (multicore processsors) and 7.1.3 (Adaptive clock frequency).	The base cases is based on products from 2005, and the figures used in the study are given as average figures for the power used by the processors at that time. There has been a change in processors since 2005, and there are also many different figures, lower and higher than 40% available for products of today, why we stick to the 40%.
6	Language on multi core technology Section 6.3.1.1 (page 165/166) refers to multi core technology and dual core technology synonymously. Multi core technology may comprise more than dual cores, so we would like to propose that you may use "multi core" rather than "dual core", where "multi core" comprises "dual core" technology.	Accepted and done
6	I would like to submit a written comment on your draft report regarding flame retardants (Section 6.3.4; Page 172). Firstly I would like to point out the German plastics manufacturers made a voluntary agreement to discontinue using PBB and PBDE already 20 years ago. As a consequence, we have built up considerable experience in using bromine/chlorine-free flame retardants as alternatives in plastics for IT-housings, including PCs, printers and TVs. Secondly I would point out that new standardization expected to come into force in the next couple of years will deal with the danger of an external ignition source - thus merely reducing heat generation of the equipment would not improve the fire safety in this case. Based on our experience, some of the comments you have made concerning flame retardants are not true of all cases. For example, a typical plastic blend produced by Bayer MaterialScience for computer housing, monitors and LCD screens contains around 15% (not 40%) of a non-brominated/chlorinated flame retardant which is not classified (ie. no R or S classification) according with EU law, yet still achieves an excellent flame retardancy (V-0 at 1.5 mm wall thickness). If a lower degree of flame retardance is targeted, then even less non-brominated/chlorinated flame retardant may be used, even to levels below 1%. These examples shows that it is possible to use non-hazardous flame retardants and in much lower concentrations than 40% for use in plastics for computer equipment. Therefore, rather than suggesting the complete deselection of plastics on account of	OK, Clarified in the report

Task	Comment	Action
	the flame retardant concentration, we would propose adding two further options for improving the ecodesign of plastics used in computers to your report: a) Replacing hazardous flame retardants in plastics with non-hazardous ones b) Reducing the concentration of hazardous flame retardants in plastics	
6	Pg 156 – "Also the power consumption when the PC is on and off will be of importance to customers" – where do you get this information from? Please state the source when making such comments. The imaging report had some interesting findings which showed that energy consumption was not something customers were particularly interested in at present. This statement is in direct conflict with the imaging report findings. "From (an) energy consumption point of view the trend has been that every new generation of PCs has consumed more than the previous generation. This is in direct conflict with the assumption made on page 149. "This trend has, however, been broken in 2006 with the introduction of multi core processors and other improvements." Where did you get this information from? Please state sources. MTP testing has shown that multi-core machines on the current market consumed substantially more in on-idle mode than single core machines. You do not explain what you mean by "built-in" PCs. Please provide an explanation. "The complexity of…..purchasing a PC" – where did this information come from? Please state source when such statements of fact are made.	Clarified in the final report
6	Pg 157 – "To be noted is that products are "best" regarding energy consumption, and that the other performances (have) not been discussed" – why is it that only energy consumption was considered? Surely this is missing out a very important part of the picture. There have been moves towards eco-PCs recently, and this approach neglects to address such trends towards changes in the BOM. "Computers are taken as the best of (the) Energy Star list of Computers "final computer dataset 10-20-06" – it should be noted that this data is anonymous, and therefore it is not possible to check to ensure that this is a real product currently on the market. The idle mode is considerably lower than the next closest computer, and the Energy Star database does not reflect this computer.	Since energy proved to be the most important issue in task 5, the focus was to minimise energy in the first place. Clarified in the report
6	Pg 158 – what is your source for the statement regarding LED technology having an energy saving potential of 25% compared to LCD technology, and on what sort of timescale is this expected to become a reality, and what guarantees are there that this will happen if they currently fail to make savings and have a lower lifetime?	Clarified in the final report
6	Pg 162 – Please elaborate on why disk fragmentation extends the life of a PC, providing sources for information. Disadvantages of enforcing frequent drive de-fragmentation is the potential time that it takes to undergo such an operation, which may result in such functionality being disabled by the user.	Reference added
6	Pg 163 "The declared idle mode is when the computer is in stand by mode with no hard disk drive operation" – this is a very misleading description, as standby mode is a type of sleep setting for computers. Needs to be reworded to avoid confusion. Please state which year these TCO figures are from, and provide reference. "These figures are very close to the sound levels given from the stakeholders in the IVF survey, where it was also stated that the monitors are quiet" – rather than stating quiet, it would be more appropriate to state a range of noise level here.	Described

Task	Comment	Action
6	Note: monitors have failed to be discussed under BAT. For consistency, these should also be addressed in section 6.2	Accepted and done
6	Pg 166 – "energy consumption could be reduced by half with a dual core processor….a substantial improvement can be seen in the multi core processors delivered today" – where does this information come from? Please state source. This conflicts with MTP testing, which found multi core machines to consume more than single core machines. Where does the figure for 30 – 40% less power consumption come from?	Reference added
6	Pg 169 – "Another benefit of a solution with a hybrid hard drive is the time it takes for the PC to start both from states S4/S5 and to boot will only be a few seconds. This would change the user pattern of a PC due to power management being enabled" - this is a naïve statement to make – user behaviour will not necessarily change just because there are better facilities for power management. There will need to be considerable user education and promotion of power management, as well as a very robust software/hardware infrastructure to support its operation. This has not been adequately discussed when power management has been mentioned. Any savings attributed to power management will be very dependent on user behaviour, and hence have a high degree of uncertainty.	We agree that education and information is needed, but stick to the comment that slow start up and boot, is one of the barriers that prevent power management. Therefore if that barrier is taken away, it may lead to an increased use of power management.
6	Pg 171 – You state that "market forces drive manufacturers to design for high brightness while most users set the brightness to a level of 125 to 150 Candela" Please state the high brightness levels manufacturers are designing for to enable comparison. Assuming user levels are much lower than this, who/what is causing the demand for high brightness if it is not something the user requires? What is your source for this information. It was previously stated that LED backlit monitors had a lower lifetime and yet in 6.3.3.1 it is stated that LEDs have a longer lifetime. Please explain the reasoning behind this – i.e. an expected timescale for LEDs to reach this level.	Clarified in the final report
6	Pg 171 – "The amount of Mercury in a normal 17" LCD monitor is 8 micrograms" – where are you getting this information from?	TCO, which is clarified in the report
6	Pg 172 – suggestion of metal monitor housing, but no discussion of the potential impacts of using metal instead of plastic, which could be just as bad.	Accepted and done
6	Pg 173 – advantages of renewable materials – could elaborate on this as some renewable materials are also biodegradable.	Accepted and done

Task	Comment	Action
6	Pg 174 – mention of battery aging – should discuss here the reasons for batteries aging i.e. battery memory and degredation of battery fluids etc. Section on new battery chemicals not numbered properly. Should also consider the impact of user education to adapt charge regimes and maximise battery life.	Battery memory is not true for laptop batteries any more (was true for Ni/Cd). Other kind of aging is described. User instructions is mentioned already
6	Pg 175 – disadvantages of OLEDs – unnecessary repetition with previous section. Statement "Not tested as a monitor for a PC yet" is unclear – surely prototype OLEDs have been tested with PCs as part of their development? Same applies for laser backlit monitors.	Clarified
6	Pg 176 - Use of lasers instead of fluorescent lighting may improve efficiency, but lasers may consume more than CFLs – justification for statement of low power consumption with lasers not made clear, and no sources provided.	References added
6	P. 155 ff: According to the VHK methodology the scope of the section is: "This entails a technical analysis not of current products on the market but on currently available technology expected to be introduced at product level within 2-3 years." Many of the improvements mentioned represent today's technology.	Agree, but since the base is technology 2005, we have to describe technologies better/newer than that.
6	P. 155 ff: There are many BAT improvements, which are not mentioned in this chapter, including: • Improved power conversion efficiency (not only power supplies, but also the voltage regulators) • Power management of monitors, which is controlled by the computer. Most computers will as default use a pause screen, which makes it impossible for the monitor to go to sleep. • Power management of computers is more than the power option settings. It also includes power management of the individual components, e.g. network card, and power management at the silicon level including clock frequency adaptation according to the computing power needs. • Design of computers without oversizing. Most computers use most of the time about 10 percent of the CPU computing power.	Described in the final report
6	We disagree with the cost estimate for an 80%+ efficient power supply of 5€ for the end user. Additionally availability is an issue for these power supplies	We estimated the price for the technology not now, but within the frame of one-two years.
6	The low power desktop noted in section 6.2.1 appears to use a laptop processor and chip set. The increase in cost (laptop components, 6 layer board) negates a good bit of the savings that come from decreased power usage	We agree. In that task, we were looking for the best available product regard-ing energy use, while completely disregarding costs.

Task	Comment	Action
6	We strongly agree with the statement that power management is a best available technology improving the energy efficiency of PCs and displays. This has been the forcus of the major IT companies the past few years. We consider this to be the prime aspect to address in any implementing measure. We also draw some attention to the fact that customer education needs to happen in the field, as power management is still disabled by too many users, although most desktops and laptops are shipped with power management enabled.	Noted
6	Enterprise network power management software can also greatly reduce the energy consumption of an average commercial desktop or laptop installation. There are case studies by vendors showing large energy savings (e.g ~10M Kwh saved on one customer installation (11000 PCs) over 4 years.	Noted
6	The elimination of screen savers has a great deal of power savings potential. According to the US. EPA, screen savers use 28% more energy than letting the monitor go to sleep.	Noted, and commented in the Final report 6.3.3
6	LED 6.2.1 Although limited amounts of products are available with LED backlights there are several issues making widespread adaptation not possible today. One is the life time, LED has less than half of the mean time between failure, another is availability. For stand-alone displays, LED backlights do not currently cut power consumption. Cost increase for these types are $100-200 depending on screen size. For white, edge-type LEDs would reduce power consumption from 19W to 15W versus a CCFL display; however the cost increase would be ~$50 for a 19" TN	Noted, and used in the final report
6	The best available technology in regards to noise (6.2.3)should be deleted. Noise is not an environmental problem for IT equipment, as no adverse affection has ever been reported on this in the literature	We keep the chapter, since noise is considered an environmental problem for IT equipment in some situations, (quiet offices, when used for media, such as film and/or music). It is also a part of the contract for this study.
6	State of the Art at Compon Component Level (6.3). ent For both a desktop and laptop PC, the processor uses around 10-15% of system power consumption during idle, not 25-40% as indicated; testing performed for energy Star and available on their website,found that the typical computer tested, spent greater than 80% time at less than 5% of CPU utilization. This information should be added.	The base cases is based on products from 2005, and the figures used in the study are given as average figures for the power used by the processors at that time. There has been a change in processors since

Task	Comment	Action
		2005, and there are also many different figures, lower and higher than 40% available for products of today. Note that the idle value is used as an indicator for when the computer is in active use, why we stick to the 40%.
6	Multi core processor technology (6.3.1.1) is indeed a valid option for improving efficiency and maintaining (or even improving) functionality. The market is absolutely transitioning to dual core processors, but care should be taken, to promote that dual core processors are going to help the environment. There is a lot of logic to dual-core and multi-core, but the driving force promoting dual-core is primarily due to the functionality. However we believe that the cost of a dual core processor is greater than 10 or 15€ quoted. Power savings of dual core processor is applications dependent. Applications that do use dual-core are high performance applications (games or video decode) which means they will cause the CPU to go to a high power state and consume more power. We realize the theory is that dual processors operating at low frequency are more efficient than a single processor operating at high frequency, but most efficient of all is a single processor operating at low frequency and supporting modest performance. Aside from gaming (and for these 2 years only, playback of high definition video) most applications thrive with a single processor.	We estimated the price for the technology not now, but within the frame of one-two years. Regarding the other comments, we have used the processor manufacturers to get information described, and not focusing of what is the case today, but what is the possible savings from such a solution.
6	For the adaptation of the clock frequency (6.3.1.2) on there could be some technical/cost/process issues: User might want to change back themselves. As this technology has been implemented in laptops already, it could be used for desktops as well. Not every processor however has the ability for adaptive clock frequency switching. It is correct that there is no system cost impact to support adaptive switching, and there are other benefits for acoustic noise and battery life. Amount of power saved will vary based on the specific technology the and application; the assumption for power savings using adaptive clock frequency assumes the processor is operating at less than its maximum power state, in fact all processors have non-working "idle between keystroke" states where the processor core is completely stopped (and the frequency it runs at is insignificant, since 0mhz is 0mhz….). The battery benchmarks used for laptops assume that the processor is in idle 85% of the time, so given a typical profile of usage the maximum power savings using adaptive frequency switching is no more than a 15% improvement at the system level. Probably, the typical Desktop processor (On, but not being used) is idle an average of 99% over the course of a day. Because adaptive switching is not available on all levels of processor, this will impact price.	There are some different ways to create the power management at processor level, we used the word adaptive clock frequency, which is only one way to do that. In the final report we changed to the wording "intensity of processor use" to open up for other solutions as well.We stick to the figures used,

Task	Comment	Action
		since there are so many different ideas of the potential, higher and lower than the ones used.
6	We disagree with the cost estimate for an 80%+ efficient power supply of 5€ (6.3.1.4). We think it is much more than the amount and to be rather around 15€ for the end user. EICTA supports long-term industry movement towards providing 80%+ efficient power supplies in desktop computers. However, we believe that there are several significant risks to proposing 80% efficient power supplies as a mandatory improvement option for EuP Lot 3 products today. Today the additional cost of an 80% efficient power supply is significant per unit. While this cost may be reduced within the next several years, there will undoubtedly be a noticeable increase in cost to the consumer if 80% efficient power supplies are mandatory across the European Union, thereby creating the possibility of industry sales volume impact. Currently power supply vendors, must use components that are not mainstream to meet the 80% efficiency requirements of Energy Star 4.0. Given the lack of history with these components, it is not clear that the power supply industry would be able to support the sheer volume that would be required to supply every desktop sold in the European region with an 80% efficient power supply by the 2008-2009 timeframe. Power savings in idle mode with an 80%+ power supply are between 12 – 15% and not 20% as mentioned. Requiring a power factor for power supplies (similar as in the Energy Star requirements) would have the additional side effect to reduce the weight of the power supply by 0.5 to 1 kg (i.e. save copper and iron) for a PC.	We do not agree with this comment, since other sources of information says different. The estimated cost is not the cost today, but within a few years of time, when these power supplies are mainstream products, sold in high volumes (which will be the case if they become mandatory within Europe). Regarding availability, the information that a development towards higher energy efficiency is needed, is already available, and forcing the industry in the right direction already.
6	For Hybrid Hard Disks (6.3.1.5) we are not aware of any desktop testing that has been done regarding flash drive use versus traditional hard drives. Some industry ources claim a 0.5 W performance improvement is possible using flash memory. However, cost could be prohibitive.	We agree
6	We disagree with the cost estimation for an 80%+ efficient power supply of 5 €. We think it is much more than 5 € and propose a value of 15€ for end-user.	Depends on the timing of the price. We estimated the price for the technology not now, but within the frame of one-two years. To be discussed.

Task	Comment	Action
6	Power savings in idle mode with an 80+ power supply are between 12 – 15% and not 20% as mentioned in the report chapter 6.3.1.4 on page 168.	Discussed at the workshop
6	EPA 4.0 also requires 0.9 as power factor for power supplies. We propose to add this requirement to EuP proposals to be consistent with EPA and with the side effect to reduce the weight of the power supply by 0.5 to 1 kg (i.e. save copper and iron) for a PC.	Discussed at the workshop
6	BAT Laptop Computer We would like to inform you about the type of laptop PC which has an idle mode power consumption of 6.8W. This type of laptop PC is called a "mobile PC" (in Japanese market). Such models are typically equipping with an Ultra Low Voltage CPU, and their design priority is battery runtime. You must realize that this type of PC does not have a major sales volume	We are aware of that, but the product described is using very little energy, and therefore the BAT regarding energy use.
6 and 7	<u>Power Savings through Adaptive Clock Frequency</u> (Section 6.3.1.2 page 166/167; also 7.1.3 page 180) AMD testing indicates up to 60% power savings at the processor level, with Cool'n'Quiet enabled	There are some different ways to create the power management at processor level, we used the word adaptive clock frequency, which is only one way to do that. In the final report we changed to the wording "intensity of processor use" to open up for other solutions as well.
7	Pg 179 – please state sources for information in charts and % savings due to dual core processors – earlier, 30 – 40% savings were quoted, but now here it has jumped up to 60% savings.	Clarified
7	Pg 180 – When mentioning Energy Star v4.0, you should state that this becomes active in July 2007. As a general trend, more efficient power supplies have become lighter, and so the BOM for a product with a more efficient power supply would be different. Some justification is needed for the assumption that this is not the case. The statement that an "80-plus" power supply will reduce idle consumption by 20% should be qualified with a source and linked to a statement of what initial efficiency of supply this is based on.	Energy star is well described in task 1
7	<u>Improvement Option « Using laptops instead of desktops (section 7.1.6; page 181)</u> In our view this improvement option is not very practical. We would like to comment that it might be much more practical as an improvement option to equip desktop computers with energy efficiency technology similar to that of laptops, so that desktop energy efficiency can be greatly improved. Also the use of small form factor desktops can be considered as a more energy efficient alternative to using desktops and therefore as an improvement potential compared to using existing (base case) desktops.	We agree.

Task	Comment	Action
7	Pg 178 – mention here that "lots of users" switch power management off – this conflicts with earlier statements which implied power management enabling rates were high. A more scientific approach to calculating savings due to power management should have been taken. A sweeping 50% savings approach is inaccurate. User profiles should be carefully evaluated against existing literature in the area to ensure that profiles are adapted for power management appropriately, without reducing on-idle time to an unrealistic amount. Careful account should have been taken at initial user profile definition stage to account for power management enabling rates when building average profiles – this does not appear to have been done. "Some peripherals lose contact.." should be followed by "with the network".	Discussed at the workshop, clarified in the report.
7	Pg 181 – Replacement of CRTs with LCDs is stated as a current trend, and yet the prevalence of CRTs in stock figures in this analysis is considerable. This conflict should be resolved. Consideration of use of laptops instead of desktops has not taken account of the trend for use of dual screens with extended desktop space – i.e. the laptop screen and another monitor both used at the same time. This should be mentioned in this analysis.	Done, and clarified
7	Pg 182 – decision not to change BOM for LED backlighting – this is not justifiable. Some clear assumptions could be made in order to change the BOM to account for the change in materials, and this is exactly the kind of analysis that should be included in this type of LCA. To assume that most improvement options will not impact the BOM is a poor assumption to make. This should be reassessed and each option carefully considered for the potential change in the BOM.	Manufacturers developing new technologies do not want to give us BOM for them. When discussing with university experts, there was no knowledge about any differences of importance in BOM. (We checked the material used for different technologies, which often are similar, at least similar enough to be used as the same material in the ecoreport tool, which does not include materials for new technologies in electronics)

Task	Comment	Action
7	Pg 183 – 7.2.2 – dual core is mentioned here – what about multi-core? Some better explanation of why the LCC is lower for desktops and higher for laptops should be provided.	Clarified in the final report
7	Pg 184 – 7.2.5 – the use of LCDs instead of CRTs is shown to increase LCC, and yet this is a very popular option currently. The discussion of results should consider how market forces can make high LCC options attractive.	Not within the scope of this study
7	Pg 188 and general – You need to state why you chose particular combinations of measures, and take a consistent approach wherever possible across all products. LCC should account for changes in the BOM if appropriate, resulting in reduced/increased product price.	Done
7	Pg 190 – You have shown very high savings for power management on laptops, and yet power management enabling rates on laptops are very high already (due to battery considerations) – therefore these savings are considerably over estimated.	Discussed at the workshop
7	Pg 199 – Conclusions are very weak. After such in depth analysis it should be possible to draw much more in depth conclusions. 7.3.10 stated that figure 21 (numbering clearly wrong) shows all the above options with LLCC – you should specify exactly what is included here. In this diagram, the savings for home PCs look too high (due to questionable stock figures for EU compared to Non-domestic PCs) and the savings potential for CRTs is excessively high, as these are becoming obsolete. Further discussion around such charts is necessary to add value to this report.	Clarified in the report
7	Pg 201 – Thin client is stated as a long term target, and yet it is currently readily available.	Yes, but not in large scale yet.
7	Pg 202 – consumer behaviour should have been addressed under the power management sections, as this is the mechanism for (and barrier to) achieving power management savings.	Yes, that would be a possibility but the consumer education is in this report separated from the hardware and software changes in products described
7	Pg 203 – selection of references is very poor and cannot possibly cover all the information referred to in these sections.	References added
7	P. 178 ff: The task is not complete according to our opinion and implementing measures should not be based on this analysis.	Read and understood
7	P. 178: The power management should be defined more comprehensively by also including power man-agement of components and at the silicon level. All types of power management are necessary for reducing the power consumption.	Agree, and described in the final report
7	P. 178 ff: Improved software has not been included but this is actually also a possible way of reducing power consumption even though it is difficult to implement. The software could be optimised in order to require less computing power, RAM and harddisk capacity etc. for the same functions, which again re-duces the power consumption.	Agree, and described in the final report
7	P. 178 ff: Using thin clients instead of desktops is a currently available improvement option and it should be included due to the impact on power consumption.	Not verified

Task	Comment	Action
7	P. 180: Regarding the power supplies, it should be added that external power supplies should comply with Energy Star if a unit using the external power supply should qualify. Only 80 Plus for internal power supplies has been mentioned.	Accepted and done
7	P. 180: Regarding the weight of the power supply, going from a linear power supply to a switch mode will reduce considerably the weight.	The input was carefully considered but did not lead to any major changes in the results or text.
7	P. 181 ff: and 187 ff Regarding using laptops instead of desktops: One laptop may for some purposes substitute two desktops in the office and in the home office. It may also provide increased work productivity due to the mobility, which has not been included in the calculations. The LLCC calculation is there-fore too simple and will not give the full and correct answer.	True for some cases. The full and correct answer can always be further evaluated. We have used the methodology described by VHK.
7	P. 187 ff: The calculation of costs is very uncertain for technologies not on the market or just been intro-duced on the market. E.g., additional costs of LED screens is assumed to be 50 EUR, but it is impossible to make a reliable assumption of a market which is just starting. Another example is the indicated extra cost of 5 EUR for an 80 plus power supply, which probably will be much lower or zero, because the in-dustry is generally moving to 80 plus power supplies.	Agree that it is difficult, but we tried to get a good estimation. Regarding PSU, there are opinions in the other directions, saying they will become much more expensive than our suggestion…
7	P. 201: Thin clients: This section is superficial and not fully correct. Thin clients comprise a currently available option and they could substitute a high degree of desktop computers. Therefore, the section should be extended in order to describe further the possibilities. Impact on the server side should be mentioned. A terminal server is needed, however, in many companies using desktop computers, terminal servers are already installed.	Thin clients was not a part of this study, why they are not described in detail.
7	Generally we believes that this task report is well written and of good quality. We agree with the proposed option to highlight power management as key improvement option for PCs and displays. For the other improvement options we think they are also well presented and make sense to us. A general change from CRT to LCD is already happening in the market, so we do not see the need to state this as dedicated improvement option.	We agree that LCD is already taking over the CRT.

Task	Comment	Action
7	We are concerned about the option for replacing desktops with laptops. Although there is a trend in this direction, desktops are chosen because the offer better possibilities for upgrading or for computational power. Additionally it has to be stated that in most of the cases a laptop will be used with an additional display, keyboard and mouse, and perhaps a docking station, so that the environmental impact of these additional equipment needs to be taken into account as well.	We agree, and that is written in the report. (for example is the amount of monitors sold higher than the amount of desktops, giving the amount of monitors used by laptops)
7	For the life cycle cost we would disagree with the cost adder of only 5€ for 80%+ power supplies (see above). Taking a more realistic 15€ for the end user into account, would make any option with 80%+ power supplies less favourable from a least life cycle cost perspective.	We do not agree with this comment, since other sources of information says different. The estimated cost is not the cost today, but within a few years of time, when these power supplies are mainstream products, sold in high volumes (which will be the case if they become mandatory within Europe).
7	The comparison of impacts and costs in chapter 7.2 and 5.3 is based on the same repair & maintenance costs per product for Desktop and Laptop. We propose to increase the value for laptops. The reason is that the laptops have higher repair & maintenance costs than desktops (reasons are mechanical stress due to different customer behaviour, mobile use, batteries, …).	That could be true. Still when asking the manufacturers, the answer was that most of the repair costs were within the guarantee, and if there comes a need for a repair at higher cost after the guarantee time, the products were not repaired but replaced, thus, laptops have a shorter life-time than desktops.

Task	Comment	Action
7	The adder of only 10 € for Dual core processor technology vs. standard processor should be confirmed by AMD/Intel. Adaptive clock (Processor) without cost adder should be confirmed by AMD/Intel.	Done. We estimated the price for the technology not now, but within the frame of one-two years. All improvements related to processors were discussed with processor manufacturers
7	The comparison of impacts and costs in chapter 7.2 and 5.3 is based on the same repair & maintenance costs per product for Desktop and Laptop. We propose to increase the value for Laptops. The reason is that the Laptops have higher repair & maintenance costs than Desktops (reasons are mechanical stress due to different customer behaviour, mobile use, batteries,…).	Discussed at the workshop. We did not receive any verified data to support the comment. Decided to stick to the values used
7	We propose also to define an efficiency figure for the CPU as the impact of the power consumption of the CPU is bigger than that of the power supply. The efficiency measurement for the power supply is clearly defined with the 80+ approach (www.efficientpowersupplies.org); however no efficiency definition is available for the CPU, yet.	Discussed at the workshop
7	Laptop power using parts On Figure10, more explanation is needed about the state of the laptop. For example, is it while the system is idle, or CPU load is high?	Accepted and done
7	Dual-core processor In the point that a Dual-core processor uses 60% less energy than a Single-core processor, you must clarify the reference you derived this from. (1) Generally it is said that a Dual-core Processor can reduce the power consumption by 60%, for the same manufacturing process, same footprint, and same performance. In other words, a Dual-core processor's performance is 1.7 times better than that of a Single-sore processor. (2) We would like to emphasize that this 60% reduction of power consumption is achieved only when the system load is high and CPU usage is 100%. This must be considered to calculate improvement by Dual-core processor because of the description in 4.3.1 ," In this study it is assumed that most of the time a computer is on, it is idle mode". (3) Please keep in mind that the total amount of heat radiation from a laptop PC is limited. Also, we must remember that processor vendors have a tendency to improve other functions that will increase the performance (Bus speed, CPU clock), which results in keeping the same power.	Discussed at the workshop.

Task	Comment	Action
7	80-plus As mentioned in the 80 PLUS web site, we must recognize that this technology is for Desktop PCs. Therefore, in chapter 7.2.4 improved power supply, we can not apply 80 Plus to laptop PCs *The 80 PLUS program has created a unique forum that is uniting electric utilities, the computer industry and consumers in a groundbreaking effort to bring energy efficient power supplies to desktop computers and servers.* Regarding the power supply unit, the ENERGY STAR standard has been adopted as regulation in several U.S. States, California included. The EnegyStar rank can be classified as Tier1 and Tier2, with Tier1 taken into effect on January-1st, 2007. The internal power supplies used for Desktop PC are not EnegyStar standard compatible. External power supply units for laptop PC have already realize Tier1; power unit efficiency rate is more than 84% when 25%, 50%, 75%, and 100% load is applied to the AC adaptor. Tier2 will be deployed on July-1st, 2008. To meet its regulation compliance, power efficiency rates and power consumption without load will be slightly improved.	Discussed at the workshop
8	Industry strongly supports Scenario 5 as possible implementing measure EICTA has together with other European industry association AeA Europe developed Ecodesign improvement options for Lot 3 The EICTA and AeA Europe options include the following suggested requirements: 80%+ efficient power supplies for desktops Requirements for EPS aligned with Lot 7 (84% efficiency, 0.75 W no load level) Power management for PCs and monitors Limits on sleep, off levels for desktops, laptops Limits on active, sleep, and off levels for monitors These improvement options have been included in the assessment as Scenario 5 and the results are shown in the report.The industry recommendations (Scenario 5) bring a substantial reduction in environmental impact. Figures 16 and 17 (see below) of the report clearly show that by implementing the improvement options suggested by industry would result in total reduction in primary energy use of ca. 18 % for desktops and ca. 14 % for laptops and nearly 15 % for all product groups (desktops, laptops, monitors) by 2020.	Your opinion
8	It has to be noted that the industry recommendation is an industry wide agreed proposal; it finds support by all relevant stakeholders and it can be implemented without any barriers to innovation, product market access barriers and with limited impact on availability and cost to the consumer. This is fully in line with the general goals of EuP.	Your opinion

Task	Comment	Action
8	Comparing the reduction in environmental impact of Scenario 5 to that by the other options (Scenario 3 possible Option A and Scenario 4 possible Option B) it becomes clear that neither Scenario 3 possible Option A nor Scenario 4 possible Option B bring a significant reduction in environmental impact for desktops and laptops. It is concerning that Scenario 3 possible Option A is not even better in environmental terms than Scenario 4 possible Option B, although Scenario 3 possible Option A requires limits on idle mode, which are very difficult to meet. It is also obvious that according to the assessment the whole labelling and information requirements do not have any positive impact on the environment.	Your opinion
8	The technical requirements set out in both Scenario 3 possible Option A and Scenario 4 possible Option B (idle mode, sleep, off levels in line with Energy Star 4.0) will cause a significant disruption on the market.Both of these options will pose a challenge to the industry to implement, will make PCs more costly to the consumer and will possibly make some product categories (gamer PCs, multimedia PCs) disappear from the European market.	Your opinion
8	Industry is strongly against Scenario 3 possible Option A, including mandatory requirements for idle, sleep, off levels in line with Energy Star 4.0 equirements EICTA and AeA Europe are very concerned and surprised that the “Scenario 3 possible option A for implementing measures” (Table 2) suggests “Mandatory minimum requirements for idle for computers in line with Energy Star tier I from 2010”. Setting minimum requirements for idle for computers has not been mentioned before in any of the task reports 1 to 7, not even in the report on “improvement potentials” (Task 7) or in the report on “best available technology” (!). This possible requirement has also not been mentioned at the public workshop on Lot 3 held in Brussels on the 20th April 2007. It is of further concern that the life cycle cost (LCC) of such a requirement has not been assessed in detail.	Implementing measures should NOT be a part of task 1-7 (which was discussed at the workshop in Brussels, April 2007), according to the methodology used.
8	Today many performance systems do not meet the Energy Star 4.0 Tier I requirements for idle, specifically systems that employ advanced graphics processing. While industry is working on this, there is no guarantee this will be resolved by the 2009 time frame. So choosing the idle limits and establishing them in an implementing measure becomes the problematic point for the supply of computers. Also, technological innovations (amongst other things software) may be implemented that cause idle mode values to be higher. A voluntary standard limiting idle, such as Energy Star would allow these systems to exist. An implementing measure on the other hand may prevent gaming systems and high end performance systems from entering the European market.The current developments in Energy Star are moving to provide a standardized tool (ECMA TC38-TG2) by 2009, which will factor in all of the power states (including idle mode) for computers and away from idle mode measurements. This tool will then be used to set limits on energy consumption of a computer according to use patterns, not to limit certain states or dictate the use of specific components such as (0%+ efficient power supplies.	Your opinion

Task	Comment	Action
8	We are also very concerned and surprised that both Scenario 3 possible option A and Scenario 4 possible option B for implementing measures (Table 2) set the requirements for sleep and off at the same levels as the Energy Star 4.0 Tier I by 2009. While industry agrees that limiting energy consumption in sleep and off are a priority, we are opposed to suggest the levels in the timeframe suggested, which are mandated for a voluntary ecolabel (Energy Star) awarded to only the top 25% of the market. We strongly suggest that if requirements for sleep and off are set, these are in line with the industry proposal outlined in Scenario 5, allowing for a tiered phase-in of the more strict Energy Star 4.0 Tier I requirements (see "Ecodesign requirement options with prolonged transition time (e.g. 4+ years out)" in Figure 13, Page 24 of Lot 3, Task 8).	Implementing measures should NOT be a part of task 1-7 (which was discussed at the workshop in Brussels, April 2007), according to the methodology used.
8	Setting minimum requirements for sleep and off for computers has not been mentioned before in any of the task reports 1 to 7, not even in the report on "improvement potentials" (Task 7) (!). This possible requirement has also not been mentioned at the public workshop on Lot 3 held in Brussels on the 20th April 2007. It is further very disturbing that the life cycle cost (LCC) of such a requirement has not been assessed in detail.	Implementing measures should NOT be a part of task 1-7 (which was discussed at the workshop in Brussels, April 2007), according to the methodology used.
8	Industry is against Scenario 4 possible Option B, including labelling requirements and mandatory requirements for sleep and off levels in li line with Energy Star 4.0. In the possible Scenario 4 possible option B for implementing measures, there is a suggestion to include information about power levels on the product, i.e. on a sticker. We are aware that business to business (B2B) customers are increasingly looking for some information on energy efficiency of the equipment they purchase and as this information can have an influence on the purchase decision. This information has to be provided before B2B customers purchase equipment (e.g. pre-sale notification). In order to respond to such demand, all major OEMs already provide detailed information on power levels (e.g. according to Energy Star) in their environmental data sheets accessible on the Internet. This information can also be used by private consumers as they are web users and the web is the place where they go to get information. We would question if energy information really influence consumer's (business to consumer, B2C) choices when provided on a sticker glued to the products leading to a tangible overall impact on power consumption.	Information about energy consumption for products is NOT easy available at the websites for most of the manufacturers according to our test. (We used several hours trying to find that kind of information for many products now available on the market. For most of the product NO information was found. For some products, we got information from our contacts at the manufacturers, about where to go for the information, and then some information was

Task	Comment	Action
		found. Ordinary customers are not likely to have such contacts…)
8	We believe that a simple sticker, as proposed in the report, does not have any benefits and it creates lot of troubles for the industry. For examples, the label will need to be localized in various languages, which will create disturbances in supply chains; the label will need to be compatible with the housing to be recyclable. This information could be provided more effectively and appropriately via the producer's website.	Your opinion
8	Unlike consumers of white goods that are fixed products, many IT consumers may customize the devices they purchase or even upgrade them at some stages of the product life cycle. This may effect the energy consumption of the device rendering any initial labeling inaccurate. We therefore oppose that the "Scenario 4 possible option B for implementing measurers" is included in this report as a valid option for policy. We suggest that specifically the limits on sleep and off are made in line with the industry suggestion and that any "labeling" be limited to providing information in the Internet and in the product documentation.	Your opinion
8	Industry is against providing superfluous information (regulated substances, neutral web page)The report recommends that it should be required to inform the consumer about personal computers' and monitors' content of restricted substances such as mercury and lead. The RoHS Directive has addressed this aspect and the RoHS Directive has no information requirement. REACH has to a certain extent requirements set down to inform customer of substances contained of very high concern in articles, as a result we believe no duplication through an EuP implementing measure is needed. The report also recommends the establishment of a neutral web page, run by the EU, or a third party, whereto all the manufacturers have to report information about certain issues. What they would to report: Power consumption in different modes (described above) Instructions (or a link to instructions) for the customer on what to do when it is time for End of life treatment. Information for all the countries where the product is sold Information about the power management system available in the product", We are concerned by the validity of such a web page, as it seems to be simply a replacement	Your opinion. We think there is a difference between voluntary initiatives, such as Energy Star, covering "their" products, and Mandatory information covering all products.
8	We request that any implementing measure will not require producers to provide information related to substances and to end of life treatment. These requirements are already set by REACH and WEEE and do not belong into EuP.	Your opinion
8	Industry concerned about the efficient power supply recommendation for dis displays/monitors plays/Currently there is no power supply efficiency standard or test procedure for displays/monitors like that referenced for desktop computers. The lack of standard limits the industry's ability to analyze the recommendation for market impact and calls into question the validity of the calculated energy savings over time. Developing and codifying such a standard with broad stakeholder representation should be a pre-cursor to policy recommendations.	Your opinion

Task	Comment	Action
8	Industry needs a realistic timeline for EuP impl implementing measures ementing Generally it has to be stated that the suggested timelines for implementing the requirements (e.g. 2009 for high efficient PSUs, 2010 for minimum idle requirements) is unacceptable for industry. The typical design cycle for PCs is in excess of 18 months. If changes affecting the silicon are needed (e.g. for idle, sleep, off limits) this time can easily add in the excess of 6 months. From the day that implementing measurers are set as law, industry will need a minimum of 24 months to prepare to meet the requirements as suggested in the task report 8. If the implementing measures will be made law in mid 2008, the earliest date the implementing measurers could take effect should be mid 2010. EICTA and AeA Europe strongly recommend that any implementing measure will not take effect before mid of 2010, contrary to the suggested timelines in the task report.	Your opinion
8	Summary: Industry strongly supports Scenario 5 as possible implementing measure Industry is committed to reducing the environmental impact that their products may have. The joint industry recommendations (Scenario 5) bring a substantial reduction in environmental impact. Figures 16 and 17 of the report demonstrate that by implementing the improvement options suggested by industry would result in a total reduction in primary energy use of nearly 20% by 2020. The industry agreed recommendation finds support from all relevant stakeholders and can be implemented without any barriers to innovation and without significant impact on availability and cost to the consumer. This is fully in line with the general goals of EuP. Industry has always aimed to partner with the EU Commission in the process of developing implementing measurers for PCs and monitors. We therefore request that the EU Commission take into consideration the industry proposal for the best approach to lowering the environmental impact of PCs and monitors in a way that is both sustainable for the environment and the industry.	The savings for the industry suggestion compared to business as usual are 16% if we add desktops, laptops and monitors. The savings for option A is 22% and for option B 21%.
8	We support your recommendation Scenario 4 Option B which means an efficiency improvement of about 21% in 2020 compared to 'Business as usual'. To be able to implement the recommended features in all our mass product lines we propose to postpone the introduction of the high efficient power supply as standard to 2010 instead of 2009 Background for this proposal is that we strongly depend on our suppliers. We can and will define the new request for high efficient power supplies as soon as the implementing measures are fixed. From this time (middle of 2008?) we need a redesign cycle of up to 2 years to be able to deliver new PCs based on the new technology. This is the main reason to postpone the introduction of the high efficient power supply as standard to 2010.	Your comment
8	Additionally we propose to chance the request for information about power levels - We think that an additional neutral web page doesn't mean any benefit for consumers or the environment. The information about power levels should be included in all data sheets and on the producer's web pages. - A power consumption sticker only makes sense for consumer products at the point of sales. So the request for a sticker should be voluntary.	The sticker with the website address, is of importance also for End of Life, since at that time, the product might be broken and all datasheets gone.

Task	Comment	Action
8	The issue concerns the proposed regulation on the efficiency of internal power supply of monitors and power factor. The Task 8 report suggests 80% minimum efficiency at 20%, 50%, 80%, 100% of rated output and power factor ≥ 0.9 of rated output. as a target under the EuP Implementing Measure. This proposal is problematic in the following two aspects. First of all, regulation on the efficiency of monitors' internal power supply is unprecedented, so industry consensus on measurement standards does not exist yet. Any regulation on the efficiency of internal power supply should address this issue, which will take considerable time. Thus the proposed timeline is not realistic. Secondly, the monitor industry is not prepared for power factor-related regulation. Our preliminary assessment is that most small monitors do not meet the proposed target (0.9 ore more), and manufacturers will have to add a PFC circuit to its power supply and redesign some products to create more space for that addition. This will increase the cost substantially without creating equivalent benefits in terms of energy saving. The Lot 3 report does not provide any cost-benefit analysis to justify the power factor regulation.	This is your opinion. It has been checked with experts, and we stick to the suggestion.
8	High performance PC and low cost PC For high performance and multifunctional PCs primarily intended for entertainment, and for business-oriented PCs with low cost CPUs that partly eliminate the power-saving function, it is impossible to meet the current idle mode specification of Energy Star Tier I. EuP Lot3 recommends requiring Energy Star Tier I in Scenario3, but PC vendors are concerned that European consumers will not purchase high performance, multifunctional PCs or low cost PCs. For such PCs, EuP Lot3 should define new categories and their criteria should be clearly defined in Task8. [Proposal1] The text about Scenario3, Idle/active level in table 2 should be changed as follows: Mandatory minimum requirements for idle for computers in line with E* tier I from 2010 -> Mandatory minimum requirements for idle for computers in line with E* tier I from 2010. <u>An additional category for high performance PCs should be added.</u>	This is your opinion. The idea of an extra product category is already mentioned
8	[Proposal 2] The text in Scenario3 should be changed as follows: Some high-end products, such as gaming computers, will have difficulties in fulfilling the requirement. Adding an extra category for this kind of products could solve this. -> Some high-end products, such as gaming computers <u>and business-oriented PCs using low cost CPUs that partly eliminate the power-saving function,</u> will have difficulties in fulfilling the requirement. Adding extra categories for those kinds of products could solve this.	This is your opinion. The idea of an extra product category is already mentioned

Task	Comment	Action
8	Proposal 3] The text in Scenario3 should be changed as follows: Minimum requirements for idle mode for computers becomes mandatory 2010 in line with Energy Star criteria, tier 1. It is assumed that all new products will comply with these requirements from 2010, leading to the full stock compliant in 2016. -> Minimum requirements for idle mode for computers becomes mandatory 2010 in line with Energy Star criteria, tier 1. It is assumed that all new products will comply with these requirements from 2010, leading to the full stock compliant in 2016. Additional categories should be added .for some high-end products, such as gaming computers, and for business-oriented PCs using low cost CPUs that partly eliminate the power-saving function.	This is your opinion. The idea of an extra product category is already mentioned. We do not agree that the business-oriented PCs using low cost CPU that partly eliminate the power-saving function should have any extra benefits.
8	Power efficiency for external power supply (laptops) EuP Lot3 recommends requiring 85% minimum efficiency for external power supply (laptops) in Senario3 and Senario4. The Energy Star external power supply specification defines the standard value by a calculation based on rated power output. For a lower rated power external power supply, the power efficiency standard value can be defined down. PC vendors are concerned that a lower rated power external power supply could not meet the EuP standard value. Eup lot3 should follow the Energy Star External Power Supply specification. [Proposal 4] The text in Scenario3 should be changed as follows: For external power supply (laptops): 85% minimum efficiency -> For external power supply (laptops): the following minimum efficiency 0 to 1 watt : $\geq$ 0.5 x Pno >1 to 51 watts: $\geq$ 0.09 x Ln (Pno) + 0.5 > 51 to 250 watts: $\geq$ 0.85 (Pno: nameplate power output)	Your opinion
8	Second step of external power supply In Senario3 and Senario4, EuP lot3 suggests 90% power efficiency as the second step of the external power supply specification. But, currently, there is no reasonable prospect (including technology, cost and procurement) that 90% power efficiency can be achieved. EuP Lot3 should delete the description recommending requiring 90% power efficiency. [Proposal 5] The text in Scenario3 should be changed as follows: As a second step it could also be recommended to make an even higher efficiency of power supply units, ~~such as +85% or +90%~~, a mandatory requirement. This would give quite a large impact on energy use, but the measure has to be further developed. ->As a second step it could also be recommended to make an even higher efficiency of power supply units a mandatory requirement. This would give quite a large impact on energy use, but the measure has to be further developed.	This is your opinion. We do not agree.

Task	Comment	Action
8	Presentation of the information In Scenario4, EuP Lot3 recommends requiring the presentation of information on power consumption and the content of restricted substances on the outer surface of the product. EuP Lot3 estimates that, by presenting this information, the energy saving would reach the same level as Senario3, but EuP lot3 should show the investigation data for assuming this.	It is an assumption made on the basis that energy is becoming more and more important for public procurement as well as for business and private customers.
8	Presentation of power consumption In Scenario4, EuP Lot3 recommends requiring the presentation of information on power consumption on the outer surface of the product. This is for the purpose of providing consumers information on performance differences between PC vendors and models. Concerning indicated power consumption information, it is important to prevent use in a misleading way by PC vendors. EuP Lot3 should clearly show “measurement conditions and methodology”, so that everybody can get the precise value of all measurements, and should show “indication requirement for power consumption information.”	The suggestion is to develop the information requirements.
8	In the text about Scenario 1 and Scenario 2, Sleep/Off level In Table 2, the words “Voluntary in E*” are used. However, in 1.1.3 on Page 12, the words “the Energy Star4.0” are used. The words “E* Tier I” should be used in Table 2.	The table 2 is only a summary, the details are described under each scenario.
8	In the text about Scenario 3 and Scenario 4, High efficient PSU in Table 2, there is no description for laptops. However, in the section “Mandatory requirements for power supply unit efficiency” in 1.1.6, there is the description for external power supply (laptops). The requirement for laptops should be also described in Table 2.	Accepted and done
8	In the text about Scenario 3 and Scenario 4, Sleep/off levels in Table 2, the words “Mandatory minimum requirement” are used. However, in the section “Minimum requirements for power modes for Computers” in 1.1.6, the words “Energy Star 4.0, Tier1” are used. The words “Energy Star Tier I,” should be used in Table 2.	This scenario include mandatory requirements, harmonised with Energy Star 4,0, Tier 1. Clarified in the report. The table 2 is only a summary, the details are described under each scenario
8	In the text about Scenario 5, Sleep/off levels in Table2, there is the description “Computers 10W and 4W sleep from 2009”. This description should be modified as “10W Sleep, 4W Off for computer”. However, according to Figure 13 in 1.1.8 “Scenario 5. Industry recommendation”, the words “4W Off” are not correct. They should be modified as “5W Off”. If the words “4W Off” are correct for the Lot3 recommendation, the reason should be clarified.	You are right! We have changed the texts to clarify.

Task	Comment	Action
8	There is a description "65% of new products fulfill the criteria in 2011". The reasons for assuming the proportion (65%) and the timing (2011) should be explained.	This is an assumption based on that the amount of new products fulfilling the criteria will start with 25% the first year and increase by 10% each year until 65% of the new products fulfil it, giving 2011. Clarified in the report
8	There is a description that the criteria are assumed to decrease the idle mode power by 10% in Scenario2 compared with Scenario1. The reason for assuming this decrease (10%) should be clarified.	Clarified in the report
8	All Requirements in 1.1.6 are to become mandatory. The titles "Minimum requirements for power modes for Computers" and "Minimum requirements for power modes for Monitors" in pages 12 and 13, should be modified as "Mandatory minimum requirements for power modes for Computers" and "Mandatory minimum requirements for power modes for Monitors" to conform to the other titles.	Accepted and done
8	The descriptions of "Sleep (S3) 1.0W/1.7W" and "Off/Standby 1.7W / 2.4W" should be modified as "Sleep (S3) 1.7W / 2.4W" and "Off 1.0W / 1.7W", as described in Task 1 Table 3 (Energy Star Version 4).	Accepted and done
8	In Sleep (S3) and Off/standby requirements, there is the description that the limitation for Sleep and Off power consumption affects performance in the case of very powerful computers. However, in Sleep and Off mode, the system is completely shutdown, so there is no affect on performance. It is not the limitation for Sleep and Off mode but that for idle power to affect the performance. The description should be modified.	We agree. We do not say that sleep and off values affect the performance, but that the high-end products of today often use much power in sleep and off and that the limitations can give much savings for that kind of products, "without hammering the product performance". We change the wording.
8	Among the requirement for idle mode power consumption, there is the description "Adding an extra category for this kind of products could solve this", related to High-end product. This is a very important requirement, and Table 2 should state that the new category needs to be defined.	We agree that it is a possible solution, but not the only one!

Task	Comment	Action
8	Requirements for PSU, power management, Idle and Sleep/off, and explained as, "This scenario is very similar to scenario 3". But the requirements should be clearly described for all items.	We have described everything clear in scenario 3, only the changes in scenario 4, to make the changes clear!
8	In Scenario 4, Eup Lot3 recommends requiring presentation of information on power consumption on the outer surface of the product. Consumer will buy products based of this information, it is important to prevent use in a misleading way by PC vendors and to prevent from "misleading by PC vendors" and "misunderstanding in the market", the appropriate measurement method and measurement condition and indication requirement for power consumption should be clearly defined in Task8. - Even for the same name model, due to system configuration differences (CPU, memory, LCD panel, etc.), power consumption will differ significantly. On the other hand, PC vendors will BTO/CTO and therefore have a huge number of system configurations. Considering the huge task involved in "power consumption measurement" and "manufacturing control for power consumption indication" for a huge number of system combinations, PC vendors will measure the power consumption for maximum configuration, and indicate on the outer surface of the product. In this case, a configuration with much lower power consumption will have the restriction that the indicated and actual power consumption significantly differ. Considering PC vendors' circumstances, the requirements for the measurement methodology, measurement conditions and indication requirements for power consumption information should be clarified. To indicate power consumption on the surface of the products, PC vendor need to consider "the worst case" that all devices, including the CPU, operate at the maximum power consumption defined by datasheet. In Energy Star case, the power consumption measurement method is managed on the basis of an agreement between EAP and PC vendors, and the Energy Star logo can be a clue for the purchase. On the other hand, if EuP Lot3 requites indication of power consumption information, the power consumption value will be a clue for purchase selection. Consumers will understand that the power consumption information is assured by the PC vendors. So PC vendors need to have enough margin for the indication of the power consumption information. Considering this kind of situation, requirements for measurement methodology, measurement conditions and indication requirement for power consumption information should be clarified.	Our suggestion is that the Energy Star measuring methods should be used, as already written in the scenario text.
8	In Table 4 Effective 2011, laptops recommended requirement is described "Sleep (S3) 1.0W/1.7W" and "Off/Standby 1.7W / 2.4W", but this is incorrect. This description should be modified as "Sleep (S3) 1.7W / 2.4W" and "Off 1.0W / 1.7W", as described in Task 1 Table 3 (Energy Star Version 4).	Accepted and done