European Commission DG TREN

Preparatory Studies for Eco-design Requirements of EuPs

[Contract N°TREN/D1/40-2005/LOT7/S07.56433]

Lot 7

Battery chargers and external power supplies

Final Report

January 23, 2007

Bio Intelligence Service - Scaling sustainable development
Industrial ecology - Nutritional health
Bio Intelligence Service S.A.S.

Project performed in collaboration with

Partner
Fraunhofer IZM
Fraunhofer Institut Zuverlässigkeit und Mikrointegration

Sub-contractor
CODDE
COnception Developpement Durable Environnement

Contact Bio Intelligence Service S.A.S.
Véronique Monier / Shailendra Mudgal
☏ + 33 (0)1 56 20 28 98
veronique.monier@biois.com
shailendra.mudgal@biois.com

Project Team

- **Bio Intelligence Service**

Ms. Véronique Monier

Mr. Shailendra Mudgal

Ms. Lea Turunen

- **Fraunhofer IZM**

Mr. Karsten Schischke

Mr. Christian Ciaglia

Dr.-Ing. Nils F. Nissen

- **CODDE**

Ms. Linda Lescuyer

Mr. Marc Janin

Content

PREFACE

External power supplies (EPS) and battery chargers (BC) are important to the operation of many electrical and electronics products. They especially accompany portable appliances which are found in increasing numbers in household and office environments. These products are estimated to consume an important portion of daily electricity consumption[1].

Apart from battery chargers sold individually for charging rechargeable batteries, EPS and BC are often delivered as a part of an end-appliance, e.g. mobile phone, laptop computer, inkjet printer, flat screen display. The end-user is rarely conscious of the energy and environmental performance of the EPS/BC and often does not have a choice as they are bundled with the end-application. The manufacturers, on the other hand, tend to focus on the main application and their approach for the design of EPS/BC is in terms of the energy requirement for the main application. Recently, the trend has been to reduce the size of EPS/BC for the portability reasons as they are often used with mobile applications. The reduction of size indeed affects their environmental performance (e.g. reduction of raw material used). Also, some voluntary initiatives such as the Code of Conduct (EU) and Energy Star have been attempting to improve their energy and environmental performance.

In this context, a horizontal preparatory study was conceived for eco-design requirement for external power supplies and battery chargers in the framework of the EuP Directive. This study attempts to analyse these products and propose the approaches and means to improve the environmental and energy performance of EPS and BC.

[1] In the U.S., it has been estimated that there are currently about five external power supplies per person. The total electricity flowing through all types of power supplies has been estimated at 6 percent of the U.S. national electric bill. (http://www.energystar.gov/index.cfm?c=prod_development.external_EPS_program)

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1. DEFINITION

The objective of this section is to present and discuss definition and scope issues related to the EuP preparatory study for the lot 7. It consists of categorisation of products, description of product definitions, scope definition as well as identification of key parameters for the selection of relevant products to perform detailed analysis and assessment during the next steps of the study.

Further, the harmonised test standards and additional sector-specific procedures for product-testing are identified and discussed, covering the test protocols for:

- Primary and secondary functional performance parameters
- Resource use (energy, etc.) during product-life
- Safety (electricity, EMC, stability of the product, etc.)
- Other product specific test procedures.

Finally, an overview of the existing legislations, voluntary agreements, and labelling initiatives at the EU level, in the Member States, and outside Europe is presented.

1.1. PRODUCT CATEGORY AND PERFORMANCE ASSESSMENT

1.1.1 PRODUCT DEFINITIONS

The established product classification schemes, such as PRODCOM, do not explicitly mention EPS and BC. The only PRODCOM category for which they can qualify is NACE 31.10 – “Manufacturing of electric motors, generators and transformers”. The major categories and sub-categories that could be of relevance to this study are listed in the Annex 1-1, but as it can be easily observed, EPS and BC do not appear explicitly in any of them. For the same reason, product definitions cannot be derived from EN or ISO standards either.

The best source for broadly accepted definitions of EPS and BC are the existing voluntary initiatives such as ENERGY STAR and EU Code of Conduct, which are presented in the following sub-sections.

It should be noted that the definitions of EPS and BC in the voluntary initiatives such as ENERGY STAR do not attempt to define these products in a global sense. They identify how certain performance criteria can be applied to these products, attempting primarily to address the EPS and BC associated with consumer and office applications.

1.1.1.1 EXTERNAL POWER SUPPLY (EPS)

For the purpose of this study, following definition of the EPS will be used.

A single voltage external ac-dc / ac-ac power supply:

- *is designed to convert line voltage ac input into lower voltage dc output / into lower voltage ac output;*
- *is able to convert to only one dc / ac output voltage at a time;*
- *is sold with, or intended to be used with, a separate end-use product that constitutes the primary load;*
- *is contained in a separate physical enclosure[1] from the end-use product;*
- *is connected to the end-use product via a removable or hard-wired male/female electrical connection, cable, cord or other wiring;*
- *does not have batteries or battery packs that physically attach directly (including those that are removable) to the power supply unit;*
- *does not have a battery chemistry or type selector switch AND an indicator light or state of charge meter (e.g., a product with a type selector switch AND a state of charge meter is excluded from this specification; a product with only an indicator light is still covered by this specification); and*
- *has nameplate output power less than or equal to 250 watts.*

This definition has been inspired from the voluntary Code of Conduct (CoC) for EPS (European Commission)[2] and ENERGY STAR[3] of US EPA.

There is a minor variation between these two definitions, the CoC definition considers only the EPS in the output range 0.3 W to 150 W compared to the upper output limit of 250 W used by ENERGY STAR.

1.1.1.2 BATTERY CHARGERS (BC)

A battery charger can be defined[4] as a *device intended to replenish the charge in a rechargeable battery. The battery charger will connect to the mains at the power input and **connect to the battery at the output**. The charger may be comprised of multiple components, in more than one enclosure, and **may be all or partially contained in the end-use product**.*

- For the purpose of the study, however, chargers integrated in the end-use product may not be analysed as it will be difficult to analyse such “internal chargers” in isolation from their main system.

In the market, based on their functional configuration following types of battery chargers exist:

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1 “Physical enclosure” refers to the housing of the products themselves, not their retail packaging.
2 Code of Conduct on Energy Efficiency of External Power Supplies, Version 2 of 24.11.2004
3 ENERGY STAR Program Requirements for EPS (version 1.1)
4 US EPA Energy Star requirement for battery charging systems

- *A La Carte Charger: A separable battery charger that is individually packaged without batteries. Batteries that the a la carte charger is designed to charge should be listed on the packaging, battery, and/or in the user materials.*
- *Multi-Voltage Charger: A battery charger that, by design, may charge a variety of batteries that are of different nominal voltages.*
- *Multi-Port Charger: A battery charger that, by design, is capable of simultaneously charging two or more batteries. These chargers also may have multi-voltage capability, allowing two or more batteries of different voltages to charge simultaneously or sequentially.*
- *Stand-Alone Charger: A battery charger that, by design, charges separable batteries disconnected from the end-use product.*
- *Batch Charger: With some multi-port chargers, such as universal AA battery chargers, single cells are charged in batches (i.e., groups of batteries charged in series).*

1.1.1.3 DISTINCTION BETWEEN EPS AND BC

In the industry, there is no consensus either about the precise differentiation between an EPS or BC. Some industries suggest that a BC is current controlled, whereas an EPS is voltage (source) controlled, but no such clear distinction exists. For example, the appliance commonly used for charging a mobile phone battery (inside the phone) is called BC by some manufacturers and EPS by others.

Technologically, EPS and BC make up a “uniform” product family. The clearest distinction between the two seems to be the product design feature:

- External power supply is connected to the end-use product via some form of wiring and does not have batteries that physically attach directly to it.
- Battery charger connects directly to the battery at the output.

ENERGY STAR also has separate program requirements for both EPS and BC. Each of them mentions that, while addressing a different set of product designs, these specifications are intended to complement each other.

> *“Manufacturers shall carefully examine their product designs and compare them to the detailed definitions and qualifying product descriptions for a battery charging system and external power supply to determine the appropriate specification for ENERGY STAR qualification. Manufacturers may only qualify individual models under the one specification (i.e., external power supply OR battery charging system) that best reflects the power supply and product design”.*

It also acknowledges that it is rather difficult to classify these products exclusively as EPS or BC and that indeed there are products that could serve the dual functions and this terminology is often used interchangeably. Examples in Box 1-1 illustrate the situation by presenting different products based on their function.

Box 1-1 – Different types of EPS and BC and their function

“Pure” EPS	An EPS which supplies a specific output voltage to **an audio system (radio, external speakers**, etc.) which has no batteries	
	A **universal EPS** with a voltage selector, polarity inverters, and changeable connectors	

EPS plugging directly into an end-appliance with incorporated batteries	A typical **“EPS” for a laptop**: According to the definition of ENERGY STAR and Code of Conduct it is clearly an EPS as it is connected to the end-use appliance (by wiring) and not directly to the battery.  Yet, the laptop contains a battery and the function of EPS is linked to charging that battery. Technically, the electronic circuitry which controls battery charging can be located either in the ‘EPS’ or in the laptop/battery. Therefore, an ‘EPS’ of this kind could be considered a charger, if it contains the charging circuitry. However, this difference is not visible from the outside.
	Typical **EPS for mobile phones**: The situation is similar to that of an EPS for a laptop. These appliances can be pure EPS if the charging control circuitry is in the battery or phone itself. According to the existing definitions they are ‘EPS’, but confusingly some mobile phone manufacturers, as well as majority of consumers call them ‘chargers’, as they are clearly used for charging a battery. 

EPS for an end-appliance with incorporated batteries, with a separate charging cradle	**An EPS for a cordless phone**: This power supply system has an EPS, which is connected to the phone cradle/stand. The function of this cradle is not always the same. Sometimes, it can be “just a cradle” and the charging circuitry is located in the phone/battery. Else, the cradle can contain the charging circuitry, thus becoming a charger itself.	
	An EPS for a digital camera: The situation is similar to the one of the cordless phone. There is an EPS, which is connected to the camera cradle/stand, which has a light showing when the battery is fully charged.	

BC for individual cells	A **charger for a digital camera battery**: This dedicated charger accepts one individual battery with specific dimensions and type.	
	A **charger for standard consumer batteries**: This charger accepts round (AA/AAA) and 9V batteries. It plugs directly to the electric grid.	
BC for a battery pack + EPS	A **battery charger for a power tool battery pack + EPS**: This battery charger (accepting a separate battery pack) has a light indicating when the battery is fully charged. The BC itself is powered by an EPS.	

1.1.2 SCOPE OF THE STUDY

In addition to the products discussed in the previous section, there are many other products, for example, industrial external power supplies, transformer in a power grid station, etc. which may be related to this product group. Also, from a technical design point of view, some other products such as, uninterruptible power supplies and ballasts, could also share similar characteristics.

It is important at this stage to clearly define the scope of the study and identify the products with similar characteristics, to be able to derive meaningful conclusions regarding design options and improvement potential during the study. A clear product group description is also important for devising the implementing measures.

The objective of this sub-section is to identify key products or product groups which will be considered in this study while performing detailed technical analysis.

1.1.2.1 PRODUCTS IN THE SCOPE OF THE LOT 7

Following are some exemplary products included in the scope of the study:

- External power supplies for consumer and office electronics, domestic lighting, computers and communication applications,
- External charging units for power tools such as electric drillers, electric screwdrivers, electric saws, etc., and
- battery chargers for household and office applications charging external/separable batteries,

within the output range of ≤ 250 W[5].

Please note that above mentioned products are just examples for illustration and other EPS/BC designed for similar function and/or having similar technical characteristics will be relevant for this study.

Recent technological developments have lead to innovative products such as EPS/BC powered by renewable sources (e.g. solar chargers) or fuel cell chargers. Such products will not be considered as base-cases for a detailed analysis, as they do not represent the most commonly available technologies and products on the market. However, they are in the scope of this study and will be considered in subsequent tasks when market trends (Task 2.3), improvement potential (Task 7), and conclusions (Task 8) are presented.

1.1.2.2 PRODUCTS EXCLUDED FROM THE SCOPE OF THE LOT 7

Following devices are excluded from the scope of this study:

- EPS/BC with the output greater than 250 W
- Internal power supplies included in the product application[6]
- Chargers for industrial applications and telecommunication network equipments and power supply units for industrial applications such as charger units which back-up the equipment and the systems (relay, engines, solenoid valves, automats, sound devices of alarm, etc.) with calls of current to maintain their permanent electrical circuits of monitoring, indication, control and operation. These products have a wide variety of output (with implications to technologies used) and generally lower production quantities.
- Individual components such as a transformer, inductor, etc. Please note that these components will of course be studied as a part of the EPS/BC system but not the component as an individual product.
- Battery chargers for vehicles (e.g. electric cars and fork lifts), as the transportation sector is outside the scope of the EuP Directive.

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5 For halogen lighting transformers, however, the output power range can extend up to 500 W and thus included in the scope of the study

6 For example, power supplies integrated for a desktop computer which might be sold as a separate component but intended to be a part of the main product

- Laptop / computer, which serves via the USB port as secondary charging/ power supply unit through USB/Ethernet for other devices such as MP3 players.
- Uninterruptible power supplies (UPS)

  The fundamental purpose of a UPS is to provide an uninterruptible source of power for the equipment it protects. UPS is designed so that there is one source of power that is normally used, called the primary power source, and another source that kicks in, if the primary source is disrupted, called the secondary power source. The power from the grid is always one of these sources, and the battery contained within the UPS is the other. A switch is used to control which of these sources powers the equipment at any given time. The switch changes from the primary source to the secondary when it detects that the primary power has gone out. It switches back from the secondary power source to the primary when it detects that the primary power source has returned. Following the definition of the EPS (see Section 1.1.1.1), UPS are not considered to be in the scope of lot 7.
- Ballasts

  Ballast is a device used with electric discharge lamps and has two basic functions. At the start up, it provides the high voltage needed to cause an arc to jump from one end of the lamp to the other. Once the arc is established, the ballast allows the lamp to continue to operate by providing the proper reduced current flow to the lamp. Looking at the definition of EPS, they are not to be considered in the scope of lot 7. Further, an existing EU regulation[7] addresses the energy efficiency of ballasts.

1.1.3 TECHNICAL PARAMETERS

The purpose of this chapter is to outline the prevailing technologies on the market for EPS/BC, as they are important parameters in the product differentiation. Detailed technical description of the functioning of an EPS/BC system is being dealt in greater detail in the system analysis (sub-task 4.4).

The basic purpose of a power supply unit, whether EPS or BC, is to convert the entering high voltage alternating current (AC) to low voltage direct current (DC) or low voltage AC. Additionally, an EPS/BC may contain the function to monitor and control the charge current (to indicate the level of charge in the batteries).

First key parameter is the technology used for the conversion of energy (applicable for both EPS and BC). For the BCs, the type of battery and the speed of charging are additional technical factors.

1.1.3.1 TECHNOLOGIES FOR ENERGY CONVERSION

There are two main energy conversion technologies for EPS/BC for consumer appliances:

7 Directive 2000/55/EC concerning minimum energy efficiency for ballast for fluorescent lighting

- Linear mode technology
- Switched-mode (also called switch-mode) technology.

Additionally, there are thyristor based devices which are mainly used for high output EPS and industrial applications.

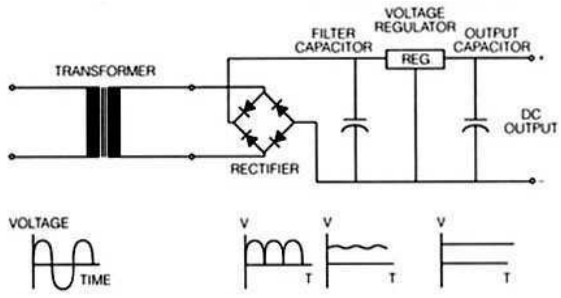
LINEAR MODE POWER SUPPLY

The basic function of a linear mode power supply is to

- **step down** AC voltage with a transformer,
- **rectify** the AC voltage into DC with a diode or diode bridge, and
- **convert** the resulting unregulated DC voltage to smoothed DC voltage through electrolytic capacitors.

A typical linear device is illustrated in Figure 1-1.

Figure 1-1 – Power supply circuit for a linear device[8]



Most of the linear power supplies are regulated power supplies. There exist unregulated linear power supplies, which are similar to regulated ones except that a bleeder resistor is used in place of the 3-terminal regulator. The disadvantage of unregulated power supply is that the output voltage is not constant and varies with the input voltage and the load current, and the ripple is not suitable for electronic applications. In case applications using unregulated power supply need a regulated voltage, a regulator is included in the product itself in the form of a specialised circuit in a standard transistor package. This indicates that certain functions of the power supply might be shifted from the external power supply unit to the product itself (or the charger base).

- **The main advantages of a linear power supply are simplicity, lower cost for low power applications and lower interference compared to a switched mode power supply (see section 3.2.2). However, they tend to be less energy efficient compared to switched mode power supplies.**

8 Source: http://www.powertronix.com/html/body_linear.html

SWITCH(ED)-MODE POWER SUPPLY (SMPS)

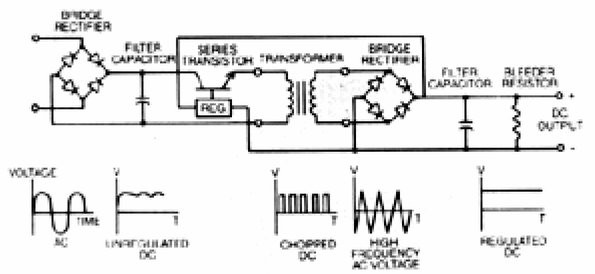
An SMPS uses a switching regulator — an internal control circuit that switches the current rapidly on and off, in order to stabilise the output voltage.

These EPS convert the 50 Hz current to a much higher frequency which enables a small transformer in the power supply to do the actual voltage step-down from 230 volts to the voltage needed by the application. The higher-frequency AC current is also easier to rectify and filter compared to the original 50-Hz AC line voltage, reducing the variances in voltage for sensitive electronic components.

The basic building blocks of a SMPS are shown in Figure 1-2 and are listed below:

- Electromagnetic interference (EMI) filter
- Input rectifier, to covert AC voltage to DC voltage through diodes or diodes bridge
- DC bus filter, to reduce the ripples of the rectified AC voltage and creates high voltage DC
- Switching element for pulse width modulation to change the energy content of the DC voltage
- High frequency transformer, in case isolation is required and to reduce the DC voltage further to the intended output level
- Secondary / output rectifier, to smoothen the pulsating to regulated DC
- Power supply control IC to control the switching element.

Figure 1-2 – Plan of a switched-mode power supply circuit[9]



Depending upon the type of input/output current, SMPS can be classified into following four types[10]:

- AC in, DC out: rectifier, off-line converter
- AC in, AC out: frequency changer, cyclo-converter
- DC in, DC out: voltage converter, or current converter, or DC to DC converter

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9 Source: http://www.mcitransformer.com/i_notes.html
10 Note: the SMPS circuits for DC input are usually only used for internal power supply units

- DC in, AC out: inverter.

SMPS can be further classified according to the circuit topology[11]. There are more than a dozen basic topologies used in practical power design. The best topology for a given application is normally based on the specific requirements for the power supply (including cost and time factors). For example, “flyback” is a typical topology for the outputs up to 150 W.

SMPS for domestic and consumer electronics products can often accept universal inputs and thus can be used in different parts of the world, with frequencies from 50 Hz to 60 Hz and voltages from 85 V to 265 V (although a manual voltage "range" switch may be required).

- **Compared to linear power supplies, the SMPS are more compact and usually more energy efficient**.

Power factor correction

The switch mode power supplies are “distortion-producing”. This means that the current waveform is not a sinewave and can have a high harmonic content. Such a current is also characterised by a high peak factor and a power factor of 0.65 to 0.8. Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than 1.

PFC returns the power factor of an electric AC power transmission system to very near unity by switching in or out banks of capacitors or inductors which act to cancel the inductive or capacitive effects of the load.

This is an important aspect in the design of SMPS beyond a certain output and is discussed in greater detail in the system analysis (sub-task 4.4).

THYRISTOR BASED DEVICES

As an alternative to linear and switch-mode EPS, the silicon controlled rectifier (SCR) or thyristor is a commonly used device for handling large amounts of power. The device consists of transistors and is far more rugged and can control much higher voltages and currents. An important feature of the thyristor is that once it is turned on it will not turn off again, even if the gate signal is removed, unless the current through the device falls to zero.

As this happens at every cycle of AC power, the controlling of the device becomes fairly simple, and is known as phase-angle firing or control. After smoothing of the resulting irregular AC wave, the output is a smaller voltage compared to the input voltage.

The main drawbacks of this device are its higher price and its bigger size and it introduces more disturbances into the supply grid compared to linear EPS.

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[11] Topology is the arrangement of the power devices and their magnetic elements

They are used mostly in the EPS for industrial and high power applications.

1.1.3.2 TECHNOLOGIES FOR BATTERY CHARGING

As explained earlier, a BC serves dual tasks: AC-DC conversion and the charging of the battery. The main technologies for current conversion have been explained under sub-section 3.2. and the present sub-section deals with battery charging techniques.

The battery charging function provides electricity to the electrodes of the battery (opposite to the direction of electron discharge), which reverses the chemical process within the battery, converting the applied electrical energy into chemical potential energy. Therefore, the technology used for a BC is also dependant on the type of batteries to be charged. Further, the market trends for the battery type and their chargers are highly correlated (see the section on market trends in Task 2).

Following are the main types of rechargeable batteries:

- Nickel-Cadmium (NiCd),
- Nickel-Metal-Hydride (NiMH),
- Sealed-Lead-Acid (SLA), and
- Lithium-Ion (Li-Ion).

Nowadays, more and more applications use Li-Ion batteries because they offer a high capacity-to-size (weight) ratio and a low self-discharge characteristic.

The following sub-sections present different charging techniques and then BCs specific to different battery chemistries. For a detailed comparative functional analysis of different type of rechargeable batteries, please refer to the sub-task 4.4 on system analysis.

Charging techniques

Charging techniques can be classified, on the basis of charging rate, into following four categories. They are also summarised in Table 1-1[12].

- **Trickle Charger** – The charge rate applied by this type of charger (lower than 0.05 C) is generally insufficient to charge a battery. Trickle charging is usually only applied after a battery is fully charged (using a greater charge rate) to help offset the self-discharge rate of the battery. Batteries on a trickle charger will maintain their full charge for months.
- **Slow Charger** - The slow charger, also known as 'overnight charger', applies a fixed charge of about 0.1 C[13] for as long as the battery is connected for a charge time of 14 to 16 hours. Slow charge rates can be applied to a battery

12 http://www.buchmann.ca/article18-page1.asp

13 “C” (nominal battery capacity rating) is the theoretical current needed to completely charge the fully discharged battery in one hour. The current that a charger supplies to the battery is normally expressed as a fraction of this theoretical current.

for an indefinite period of time, meaning that the battery can be connected to the charger for days or weeks with no need for special shut-off or current-limiting equipment on the charger. Slow chargers are found in cordless phones, portable CD players and similar consumer electronic products.

- **Fast Charger** - This kind of chargers offer shorter charge times. At 1C charge rate, an empty NiCd or NiMH typically can be charged in about an hour. Fast chargers also provide an accurate full-charge detection i.e. once the battery is fully charged, the charger switches to topping, which applies a moderate charging current that boosts the battery up to its full-charge, and then trickle charge. Fast chargers are used for industrial equipment such as two-way radios, medical devices and power tools.
- **Quick Charger** - The quick (or rapid) charger is in between slow and fast chargers, both in terms of charging time and price. Typical charging may take 3 to 6 hours and when fully charged, the battery switches to trickle charge. Quick-chargers accommodate nickel- or lithium-based batteries and are commonly used for consumer electronic products where the battery needs to be recharged quickly, such as mobile phones, laptops, and camcorders.

Quick and fast charging rates (over 0.2 C) can be used to charge many kinds of rechargeable batteries. Many chargers of this type have current limiters built into them which slowly reduce the current as the battery is charged. This prevents damage or deterioration, which can occur in the battery if the high charge rates are applied after the battery has approximately 85% of its charge restored.

Table 1-1 – Charge rates for different types of battery chargers

Charge Rate Description	Charge Rate (Amperes)	Nominal Charge Time (Hours)
Trickle (Standby)	0.01 – 0.03 C	100 to 33
Slow (Overnight)	0.05 – 0.1 C	20 to 10
Quick	0.2 – 0.5 C	5 to 2
Fast	≥1 C	1 and less
"C" (nominal battery capacity rating) is the theoretical current needed to completely charge the fully discharged battery in one hour. The current that a charger supplies to the battery is normally expressed as a fraction of this theoretical current.		

Smart charging

Increasingly, battery chargers employ some type of **smart charging** technology. 'Smart battery charger' integrates a microcircuit that permits the charger to communicate with a compatible 'smart battery' and to alter its charging characteristics in response to information provided by the battery. There are two types of Smart Battery Chargers:

- Smart Battery Charger interprets the Smart Battery's messages. The charger adjusts its output characteristics in direct response to the charging voltage and charging current messages it receives from the battery. The Smart Battery is responsible for initiating the communication and for providing the charging algorithm to the charger. The charging algorithm in the battery may simply request a static charge condition or may choose to periodically adjust the charger's output to meet its present needs.

- Smart Battery Charger not only interprets the Smart Battery's messages, but it can determine the charging voltage and current the battery desires, and then dynamically adjust its output to meet the battery's charging requirements. It may also interrogate the Smart Battery for any other relevant data, such as time remaining to full charge, battery temperature or other data used to control proper charging or discharge conditioning.

In principle, smart battery charging technology allows the charger to set the appropriate charge current and charge voltage according to the needs of the battery and to choose the correct charge algorithm. It allows batteries to be charged as rapidly and as safely as possible and also allows the use of new and different battery technologies in existing equipment. However, the “smartness” of the ‘smart battery chargers’ marketed as such varies considerably. For example, some allow only one battery chemistry while others are suited for multiple chemistries.

NICD AND NIMH BATTERY CHARGERS

NiMH and NiCd chargers can use smart battery charger or slow (overnight) battery charging configurations. Further, quick and fast chargers are also available for these batteries offering reduced charging times, down to 10 minutes.

NiCd charger

Nickel-cadmium batteries require special chargers because NiCd batteries absorb heat during the first quarter and then emit during the rest of the charge cycle, as opposed to most other batteries, which generate heat throughout their recharge cycle. If constant current is applied past the point when the battery reaches approximately 85% of its fully charged state, the excess heat will cause “thermal runaway” to occur, leading to permanent battery damage. Following are the key issues related to NiCd battery chargers[14]:

- In the case of trickle or slow charge techniques, the heat build-up is minimal and is normally dissipated by atmospheric convection before thermal runaway can occur. Consequently, many chargers supplied with, or as a part of rechargeable devices using NiCd batteries are slow chargers.
- When quick or fast charging techniques are used with NiCd batteries, the BC usually has a temperature or a voltage sensor that can detect when the battery is approaching thermal runaway condition, and thereby it reduces or shuts off the current entering the battery.
- In order to charge empty NiCd cells, the timed-charge method can also be used. Due to the fact that NiCd cells can accept very large charge rates (as high as 20 C), a timed-charge charger provides high-rate current to the cell for a limited period of time after which a timer cuts off the charging current.

[14] New Technology Batteries Guide, NIJ Guide 200-98, National Institute of Justice, U.S. (1998)

Some NiCd cells can be fully charged in as little as 10 minutes. It is crucial for this method that the cell is completely discharged at the beginning of the charge cycle, and therefore some timed-charge chargers have a special circuit designed to discharge the cell completely before charging it and these are called dumped timed-charge chargers.

- Pulsed charge-discharge chargers intend to charge a battery to attain its maximum level of charge. In this method, a relatively high charge rate (approximately 5 C) is applied until the cell reaches a voltage of 1.5 V. The charging current is then removed and the cell is rapidly discharged for a brief period of time (usually a few seconds). This action depolarises the cell components and dissipates any gaseous build up within the cell. The cell is then rapidly charged back to 1.5 V. The process is repeated several times until the cell's maximum charge state is reached. The greatest difficulty of this method is that the maximum voltage of a NiCd cell will vary with several outside factors such as the cell's recharge history and the ambient temperature. Since the cell's maximum potential voltage is variable, the level to which it must be charged is also variable. However, integrated circuits can be provided to compensate for such variations.

NiMH chargers

Chargers for NiMH batteries are similar to NiCd but require more complex electronics design. Following are the important concerns for NiMH battery chargers:

- An NiMH charger produces a very small voltage drop at full charge and the negative delta voltage (NDV) is almost non-existent at charge rates below 0.5C and elevated temperatures. Aging and degenerating cell match diminish the already minute voltage delta further. Thus, a temperature gauge is required in their charge regime (preferably a dT/dt method).
- A NiMH charger must respond to a voltage drop of 8 to 16mV. Making the charger too sensitive may terminate the fast charge halfway through the charge because voltage fluctuations and noise induced by the battery and charger may defeat the NDV detection circuit. Most of today's NiMH fast chargers use a combination of NDV, rate-of-temperature-increase (dT/dt), temperature sensing, and timeout timers. The charger utilises whatever comes first to terminate the fast-charge.
- NiMH batteries that are allowed a brief overcharge deliver higher capacities than those charged by less aggressive methods. The gain is approximately 6 percent on a good battery. The negative impact of overcharging is a shorter cycle life (300 instead of 350-400 service cycles).
- NiMH battery charger should be rapid rather than slow one. Because NiMH does not absorb overcharge well, the trickle charge must be lower than that of NiCd and is set to around 0.05C. This explains why the original NiCd charger cannot be used to charge NiMH batteries.
- It is difficult, if not impossible, to slow-charge a NiMH battery. At a C-rate of 0.1C and 0.3C, the voltage and temperature profiles fail to exhibit defined characteristics to measure the full charge state accurately and the charger must rely on a timer. Harmful overcharge can occur if a partially or fully

charged battery is charged with a fixed timer. The same occurs if the battery has aged and can only hold 50 instead of 100 percent charge.

- Lower-priced chargers may not apply a fully saturated charge. The full-charge detection may occur immediately after a given voltage peak is reached or a temperature threshold is detected. These chargers are commonly promoted on the merit of short charge time and moderate price. Some ultra-fast chargers also fail to deliver full charge.

SEALED LEAD ACID (SLA) BATTERY CHARGERS

Lead acid charger output can range from 500 milliamps up to 4 amps. SLA chargers have a universal input and utilise a constant current/constant voltage/float charging algorithm. Battery packs that are empty will start charging in a "fast charge" mode until it reaches a certain percentage, and then will decrease until fully charged.

These chargers protect batteries from overcharging, thus increasing the life span. Other features include protection from reverse polarity as well as short circuiting.

LITHIUM-ION BATTERY CHARGERS

Lithium-ion batteries have a large advantage over both NiMH and NiCd batteries as they weigh less, take less space, and deliver more energy. The main advantage of Li-ion technology is the pronounced increase in energy density it offers. Energy density is measured both volumetrically and gravimetrically. Li-ion technology can provide a volumetric energy density of almost 500 Wh/L and a gravimetric energy density of 200 Wh/kg.

Having a unique chemistry, Li-ion technology presents different design constraints than the other battery technologies such as nickel–metal hydride (NiMH), nickel-cadmium (NiCd), and sealed lead-acid (SLA). For Li-ion cells, a constant current/constant voltage (CC/CV) charge algorithm is recommended. Final termination for this charge process occurs when the charge current falls below a minimum current threshold or a timer expires.

Typically, 60–75 minutes of charging at 1C to 4.1 V is sufficient to bring a Li-ion–powered device from a depleted energy state up to an 80–90% state of charge. With the other technologies, unless the cells are specifically made for high-current charging, getting up to the same 80–90% charge might require charging for several additional hours. To obtain the remaining 10–20% of capacity, the Li-ion battery is slow-charged for an additional 4–5 hours to 4.2 V. This charging method offers two benefits. A close-to-full charge can be achieved in a very short period of time, and the voltage at the end of the charge is normally guaranteed not to exceed 4.2 V.

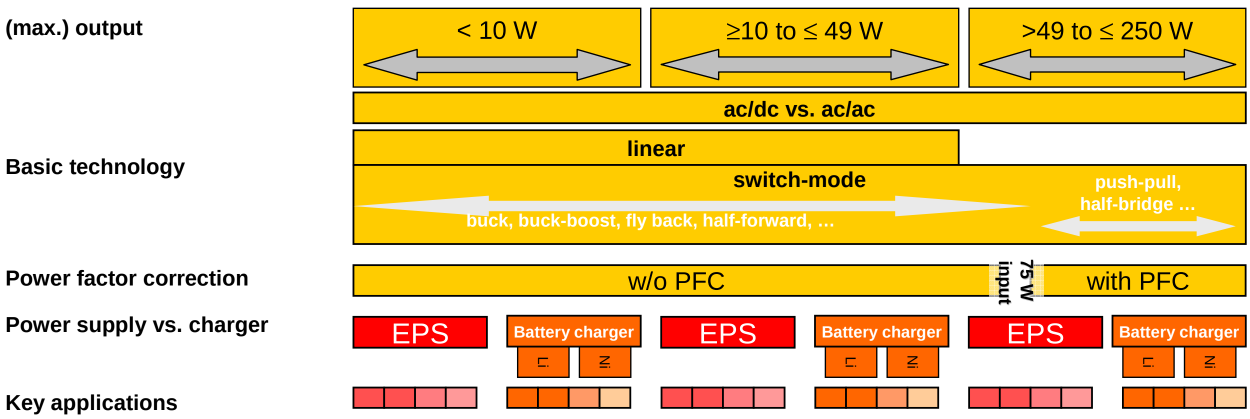
1.1.4 SUMMARY OF PARAMETERS FOR EPS/BC CLASSIFICATION

In order to categorise the products in the scope of Lot 7 study, performance parameters are to be considered. The first parameter for classifying EPS/BC is the power output range, as their purpose is to supply energy to an end-use appliance or a battery. After this first output range based classification, the product categorisation can be done on the basis of end-applications (or end devices) and their load requirements. End-application is an important aspect as it very much dictates the technical specifications of an EPS/BC, which are required for correct functioning of the end-application.

Further, the use patterns and thus the energy consumption of EPS and BC are also closely linked to the use patterns of the end-applications, an aspect under investigation under the Task 3.

Additional criteria to be taken into account while analysing these products are technology, topology, power factor correction requirement, variations within the output ranges, and battery charging properties. To what extent these criteria affect the energy and environmental performance and costs will be the focus of the next steps during this study. The key parameters, issues for the product identification, and the scope of lot 7 are illustrated in Figure 1-3.

Figure 1-3 – Summary of parameters and issues for the scope of lot 7



The functional parameters such as power output range, amount of power consumed per year, the charge rate (in the case of BC), etc., on which any future implementing measures can be based will be refined further on the basis of base-case analysis and will be presented in subsequent sections.

1.1.5 PRODUCT PERFORMANCE PARAMETER (FUNCTIONAL UNIT)

Product performance parameters are the quantified performance of a product system for use as a reference unit in a life cycle assessment. The most important is the primary product performance parameter (i.e. functional unit) which is based on functional performance characteristics and not on the basis of technology.

The functional unit for the lot 7 can be the quantity of power delivered with respect to some "other parameters". Looking at the diversity of products and end applications involved in the lot, the approach has to be more horizontal in nature without taking into account the specificities of the end application (e.g. rating of energy requirement of the application) and/or components (e.g. battery chemistry, charging mechanism, etc.). Also the adopted functional unit should be applicable to both EPS and BC in a similar manner.

The proposed functional unit is the **effective amount of energy delivered (watts) for a specific time duration (hours)**.

1.2. TEST STANDARDS

A "test standard" is a standard that sets out a test method, but that does not indicate what result is required when performing that test.[15] Therefore, strictly speaking, a test standard is different from a "technical standard". Namely, in technical use, a standard is a concrete example of an item or a specification against which all others may be measured or tested. Often it indicates the required performance.

However, "test standards" are also (but not exclusively) defined in the "technical standard" itself. For example, an ISO standard for a certain product or process gives the detailed technical specifications, which are required in order to conform to this standard. It also defines test standards (or rather methods) to be followed for validating any such conformity.

A standard can be either product or sector specific, and it can concern different stages of a product's life cycle. Thus, for each standard presented below, the scope (product and/or sector specific) and the life cycle stages which the standard deals with (manufacturing/distribution/use/end of life) are given.

EN/CENELEC internal regulations define a standard as a document, established by consensus and approved by a recognised body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards should be based on consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits. The European EN standards are documents that have been ratified by one of the three European standards organisations, CEN[16], CENELEC[17] or ETSI[18].

In addition to "official" standards, there are other sector specific procedures for product testing, which could be considered as standard when it has become recognisable both by the sender and the receiver, that is, when they are using the same parameters or standards. Those procedures are discussed later in this

15 www.deh.gov.au/settlements/waste/degradables/glossary.html
16 CEN - European Committee for Standardisation
17 CENELEC - European Committee for Electrotechnical Standardisation;
18 ETSI - European Telecommunications Standards Institute

chapter. At present, they are the most specific directions when it comes to energy efficiency/consumption testing of battery chargers and power supplies.

1.2.1 EUROPEAN EN STANDARDS

The "New Approach", defined in the European Council (EC) Resolution of May 1985, introduced, among other things, a clear separation of responsibilities between the EC legislator and the European standards bodies (CEN, CENELEC, ETS) in the legal framework allowing for the free movement of goods[19]:

- EC directives define the "essential requirements", e.g., protection of health and safety, which goods must meet when they are placed on the market.
- The European standards bodies have the task of drawing up the corresponding technical specifications meeting the essential requirements of the directives; compliance with the standard will provide a presumption of conformity with requirements of the directive. Such specifications are referred to as "harmonised standards".

A European standard adopted by CEN, CENELEC or ETSI, implies an obligation of implementation as an identical national standard and withdrawal of conflicting national standards.[20] Standards discussed in the following sections are summarised in Table 1-2.

Table 1-2 – List of relevant standards and product testing procedures

TYPE	STANDARD
European Standards	
Energy Use	EN 62301 (2006): Household electrical appliances – measurement of standby power
Safety	IEC 61204-7 (2006): Low voltage power supplies, dc output. part 7: safety requirements
	EN 60065 (2001): Audio, video and similar electronic apparatus-safety requirements
	EN 60950-1 (2001) + amendment 11 (2004): Information technology equipment – safety – part 1: general requirement
	EN 60335-1 (2002): Household and similar electrical appliances – safety –part 1:general requirements
Electromagnetic Compatibility	EN 61204-3 (2000) Low voltage power supplies, dc output. part 3: electromagnetic compatibility (EMC)
International Standards	
Energy Efficiency/ Consumption	IEEE 1515-2000: Recommended practice for electronic power subsystems: parameter definitions, test conditions, and test methods

19 http://ec.europa.eu/comm/enterprise/newapproach/standardization/harmstds/index_en.html
20 http://www.cenorm.be/cenorm/index.htm

TYPE	STANDARD
Electro-Technical Standards	IEEE 519 (1992): Recommended practices and requirements for harmonic control in electrical power systems JIS C 9901 (2004) **Japan**: Method of calculation and representation of energy efficiency standard achievement percentage of electrical and electronic appliances. UL 1012 (1994) **USA**: Safety Standard for Power Units other than Class 2 (edition 6)
	UL 1310 (1994) **USA**: Safety Standard for Class 2 Power Units (edition 4)
Other Sector-Specific Procedures for Product Testing	
USEPA	Test method for calculating the energy efficiency of single-voltage external AC-DC and AC-AC power supplies (08/2004) Test methodology for determining the energy performance of battery charging systems (12/2005)
California Energy Commission	Energy efficiency battery charger system test procedure

1.2.1.1 TEST STANDARDS ON ENERGY USE

For each standard, the scope, life-cycle phase applicability, and the energy/environment aspect is also identified.

The scope of each standard can be:

Product specific: referring to a specific family or type of product.

Sector specific: document referring to a EEE sector in general.

EN 62018: POWER CONSUMPTION OF INFORMATION TECHNOLOGY EQUIPMENT – MEASUREMENT METHODS

Defines the test methods to be used to measure power consumption of information technology equipment (ITE) under various modes of operation for the purpose of energy management. Corresponds to the International Standard IEC 62018:2003.

Scope: Product specific

The standard is applicable to information technology equipment (ITE) where ITE includes the products identified in the scope of IEC 60950-1: mains-powered or battery-powered information technology equipment, including business equipment and associated equipment, with a rated voltage not exceeding 600V. It is also applicable to such equipment designed and intended to be connected directly to a telecommunication network and forming part of a subscriber's installation.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of energy consumption for the use phase of the ITE.

The environmental aspect of the product that can be impacted by the standard: Energy consumption of the product and material content.

EN 62087: METHODS OF MEASUREMENT FOR THE POWER CONSUMPTION OF AUDIO, VIDEO AND RELATED EQUIPMENT

Defines the different modes of operation relevant for the measurement of power consumption. The methods of measurement are only applicable for equipment, which can be connected to the mains. The measuring conditions in this standard represent the normal use of the equipment and may differ from specific conditions, for example as specified in safety standards. Corresponds to the International Standard IEC 62087:2002.

Scope: Product specific

The standard is applicable to mains powered AV equipment, including TV receivers, VCRs, Set Top Boxes (STBs), audio equipment and multi-function equipment for consumer use. Its objective is to specify methods of measurement for the power consumption of these equipments.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of energy consumption for the use phase of the equipment.

The environmental aspect of the product that can be impacted by the standard: Energy consumption of the product and material content.

EN 62301 (2006): HOUSEHOLD ELECTRICAL APPLIANCES – MEASUREMENT OF STANDBY POWER

Adapted from IEC 62301 (2005) standard of the same name, the standard specifies methods of measurement of electrical power consumption in standby mode. It specifies the general conditions for measurements (test room, power supply, supply-voltage waveform and power measurement accuracy) as well as selection and preparation of appliance/equipment for measurement, and test procedure.

Scope: Product specific

The standard is applicable to mains powered electrical household appliances. The objective of the standards is to provide a method of test to determine the power consumption of a range of appliances and equipment in standby mode. The standard defines “standby” mode as the lowest power consumption when connected to the mains.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of energy consumption for the use phase of the equipment.

The environmental aspect of the product that can be impacted by the standard: Energy consumption of the product and material content.

1.2.1.2 STANDARDS ON SAFETY

Standards on safety are indirectly linked to the study as they could introduce some requirements that affect the design of the product. For example, using constructional materials having appropriate flammability properties for their purpose may introduce brominates flame-retardants. Also the prevention of user access to parts at hazardous voltages, by fixed or locked covers, is a recommendation of such standards, which could however reduce the potential of recycling. By identifying them, we could also identify product family, which respect the same technical constraints. This information will be useful for the differentiation of product-cases.

Those standards are mainly used by designers and they are listed in this report in order to identify standards that could be useful for future requirements or testing measures for EuP directive implementation. Complementary safety standards are mentioned in Annex 1-2.

IEC 61204-7 (2006): LOW VOLTAGE POWER SUPPLIES, DC OTPUT. PART 7: SAFETY REQUIREMENTS

Further efforts at harmonisation are under way with IEC developing a new standard, IEC 61204-7, which is intended for use with power supplies sold into multiple industries. It will eventually become an EN standard for use in proving compliance with the Low Voltage Directive. The new standard is based on IEC/EN 60950, IEC/EN 61010-1, IEC/EN 60601-1, IEC/EN 60065 and UL 1801 (Centralised DC Power Distribution System for Telecoms).[21] At present, the document is at the stage of a Final Draft International Standard (FDIS) and it has been submitted for CENELEC for vote (circulation closing 26 May 2006).

Scope: Sector specific

This international standard describes a method for specifying requirements for low-voltage power supply devices (including switching types) providing DC output(s) up to 200 V DC, at a power level of up to 30 kW, operating from AC or DC source voltages of up to 600 V. The devices are for use within class I equipment or for free-standing operation when used with adequate electrical and mechanical protection.

This standard is intended to be used for all types of AC or DC driver power supplies with any number of outputs, specially produced for an unknown final application. In the case where power supplies are developed as a component of equipment covered by specific product standards, these standards apply.

The life cycle phase which is the concern of the standard: Use phase

This standard underlies principles of safety requirements which are to guide designers to engineer safe equipment for the use or the maintenance.

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21 EPSMA (2005) CE Marking Guidance for Power Supplies.
Available at: http://www.epsma.org/pdf/ce%20marking_march%202002.pdf

The environmental aspect of the product that can be impacted by the standard: Material content

The application of this standard will influence the specification and choice of the product material content. The level of flammability could also impacts the composition in particular regarding the hazardous substances.

EN 60065 (2001): Audio, video and similar electronic apparatus – Safety requirements

Scope: Product specific

This international safety standard applies to electronic apparatus designed to be fed from the mains, from a supply apparatus, from batteries or from remote power feeding and intended for reception, generation, recording or reproduction respectively of audio, video and associated signals. It also applies to apparatus designed to be used exclusively in combination with the above-mentioned apparatus. This standard primarily concerns apparatus intended for household and similar general use but which may also be used in places of public assembly such as schools, theatres, places of worship and the workplace. Professional apparatus intended for use as described above is also covered unless falling specifically within the scope of other standards.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of parameters for the use phase of the equipment: input; electric strength; earth continuity; touch current; humidity; heating; flammability; stability; stress relief; drop; steady force; steel ball; abnormal; over-voltage; accessibility; durability

The environmental aspect of the product that can be impacted by the standard: Material content

The application of this standard will influence the specification and choice of the product material content. The level of flammability could also impacts the composition in particular regarding the hazardous substances.

EN 60950-1 (2001) + Amendment 11 (2004): Information technology equipment – Safety – Part 1: general requirements

The EN 60950-1 standard was originally adopted from the harmonised standard IEC 60950-1 (third edition), which, upon its release in 1999, was quickly adopted by most countries and is today the primary standard for safety for most, but certainly not all, users of power supplies. In addition to IEC and EN, designations of this standard can be found as UL (United States), and CSA (Canada). EN 60950-1 includes the basic requirements for the safety of information technology equipment.

Scope: Product specific

EN 60950-1 is applicable to mains-powered or battery-powered information technology equipment, including business equipment and associated equipment, with a rated voltage not exceeding 600V. It is also applicable to such equipment designed and intended to be connected directly to a telecommunication network and forming part of a subscriber's installation.

EN 60950-1 specifies requirements intended to reduce risks of fire, electric shock or injury for the operator and layman who may come into contact with the equipment and, where specifically stated, for a service person. It is intended to reduce such risks with respect to installed equipment, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of parameters for the use phase of the equipment: input; electric strength; earth continuity; touch current; humidity; heating; flammability; stability; stress relief; drop; steady force; steel ball; abnormal; over-voltage; accessibility; durability

The environmental aspect of the product that can be impacted by the standard: Material content

The application of this standard will influence the specification and choice of the product material content. The level of flammability could also impacts the composition in particular regarding the hazardous substances.

EN 60335-1 (2002): Household and similar electrical appliances – Safety –Part 1: General requirements

Scope: Product specific

This standard deals with the safety of electrical appliances for household and similar purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances.

The life cycle phase which is the concern of the standard: Use

The standard is dedicated to the measurement of parameters for the use phase of the equipment: input; electric strength; earth continuity; touch current; humidity; heating; flammability; stability; stress relief; drop; steady force; steel ball; abnormal; over-voltage; accessibility; durability

The environmental aspect of the product that can be impacted by the standard: Material content

The application of this standard will influence the specification and choice of the product material content. The level of flammability could also impacts the composition in particular regarding the hazardous substances.

1.2.1.3 Standards on electromagnetic compatibility

Electromagnetic compatibility is the capacity of the application to work without disturbances (immunity) and without disturbing (emission) other equipment due to electromagnetic disturbances and electric wires and radiated from the enclosure. The power factor tells how much power is going back into the supply during the 50-hertz operating cycle of the appliance. A higher power factor is more energy efficient because it reduces losses in electricity distribution systems. It also saves money for the user because it minimises demand charges for electricity.

EN 61204-3 (2000) Low voltage power supplies, DC output. Part 3: Electromagnetic compatibility (EMC)

The Part 3 of EN 61204 specifies electromagnetic compatibility (EMC) limits and test methods for power supply units (PSUs) providing dc output(s) up to 200 V at a power level of up to 30 kW, operating from ac or dc source voltages of up to 600 V. It includes limits for electromagnetic emissions which may cause interference to other electronic equipment (e.g. radio receivers, measuring and computer devices), as well as electromagnetic immunity limits for continuous and transient conducted and radiated disturbances including electrostatic discharges. The standard also specifies general requirements and test conditions.

Scope: Sector specific

The standard divides the PSUs into five technology group and specifies a set of test for emissions/immunity for each group, as it is “neither reasonable nor necessary to apply all EMS tests to all PSU technologies” since they differ greatly. The EN 61204-3 is relevant for ‘PSU intended for free-standing operation’ (individual apparatus), as well as for ‘component power supplies, which are considered to be equivalent to apparatus’ (e.g. PSUs with integral mains and/or IT equipment connectors that are sold to the general public for use with printers, etc.). However, regarding ‘component power supplies intended for a professional assembler/installer’ (not intended to be accessible to the final user) the standard is to be used as an aid. It may be replaced by an end-product EMC standard.

The life cycle phase which is the concern of the standard: Use phase

Among the normative documents, which constitute provisions of EN 61204-3, are test requirements for example for harmonics and flicker, referring to the following specifications among others:

- EN 61000-3-2 (2000 + Amendment 2: 2005) Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions equipment with input current ≤ 16 A.
- EN 61000-3-3 (1995 + A1: 2001 and A2: 2005) Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection.
- EN 61000-4-2 (1995) Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques. Electrostatic discharge immunity test.
- EN 61000-4-3 (2000) Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques. Radiated, radio-frequency, electromagnetic field immunity test for general purposes; particular considerations are devoted to the protection against radio-frequency emissions from digital radio-telephones.
- EN 61000-4-5 (1995) Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques. Surge immunity test.

The environmental aspect of the product that can be impacted by the standard: Material content and energy consumption of the product

The application of this standard will influence the specification and choice of the product material content. For example, to reduce the harmonics, it is possible to add some filters. The energy efficiency of the product could also be impacted.

EMC SPECIFICATIONS IN PRODUCT STANDARDS

EN 61204-3 is general standard for power supplies today and widely applied. However, EMC specifications in product family specific standards may also apply to a power supplier. However, this is more the case with component power supplies than with EPS and battery chargers. Thus, a list of these standards can be found in Annex 1-3 – Product specific EMC Standards.

1.2.2 INTERNATIONAL STANDARDS

An international standard is a document established by consensus, and approved by a recognised body, that provides, for common and repeated use, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

1.2.2.1 ENERGY EFFICIENCY/CONSUMPTION STANDARDS

IEEE 1515-2000: RECOMMENDED PRACTICE FOR ELECTRONIC POWER SUBSYSTEMS: PARAMETER DEFINITIONS, TEST CONDITIONS, AND TEST METHODS

This IEEE[22] standard provides background on general test conditions by standardising on specification language.

Scope: Sector specific

The scope of the standard covers a broad range of DC-to-DC and AC-to-DC power systems up to 600Vdc and up to 20kW, intended for use with digital, analogue and RF electronics. It is referenced e.g. by the test method in section 1.2.4.1.

The life cycle phase which is the concern of the standard: Use phase

The standard is dedicated to the measurement of energy consumption for the use phase of the equipment.

The environmental aspect of the product that can be impacted by the standard: Energy consumption of the product

22 IEEE: the Institute of Electrical and Electronics Engineers. IEEE, a non-profit organization, is the world's leading professional association for the advancement of technology.

1.2.2.2 ELECTROTECHNICAL STANDARDS

Many of the international IEC standards have been adopted as EN standards, e.g. IEC 62301 and IEC 60950-1, which correspond to the EN standards explained in above sections.

IEEE 519 (1992): RECOMMENDED PRACTICES AND REQUIREMENTS FOR HARMONIC CONTROL IN ELECTRICAL POWER SYSTEMS

IEEE 519 is the North American recommended practice for harmonic levels.

The aim of IEEE 519 is to establish goals for the design of electrical systems that include both linear and non-linear loads. The document describes the voltage and current waveforms that may exist throughout the system and establish waveform distortion goals. It defines the interface between sources and loads as the point of common coupling with observances of the design goals to minimise interference between electrical equipment.

Scope: Sector specific

This document applies to all types of static power converters used in industrial and commercial power systems.

The life cycle phase which is the concern of the standard: Use phase

The standard addresses the problems involved in the harmonic control and reactive compensation of such converters. Limits of disturbances to the AC power distribution systems that affect others equipments and communications are recommended. Voltage and current harmonics limits total and single harmonic as well as the voltage flicker limits of irritation curves are referenced for both utility practice and DG requirements.

The environmental aspect of the product that can be impacted by the standard: Material content and energy consumption of the product

The application of this standard will influence the specification and choice of the product material content. For example, to reduce the harmonics, it is possible to add some filters. The energy efficiency of the product could also be impacted.

1.2.3 THIRD COUNTRY TEST STANDARDS

1.2.3.1 TEST STANDARDS ON ENERGY USE

AS/NZS 4665.1: TEST METHOD AND ENERGY PERFORMANCE MARK

This test standard specifies the method of test to assess the energy performance of external power supplies, and the international system for marking the efficiency on the power supply in the framework of the Australian/New Zealand minimum energy performance standard for EPS (and for the moment, also for transformers for halogen lighting).

This test method was adapted from and is technically identical to the test method used by the US EPA in the ENERGY STAR program (see Section 1.2.4.1).

1.2.3.2 ELECTROTECHNICAL STANDARDS IN OTHER COUNTRIES

JIS C 9901 (2004)[23] – JAPAN

Method of calculation and representation of energy efficiency standard achievement percentage of electrical and electronic appliances.

UL 1012 (1994) – USA: SAFETY STANDARD FOR POWER UNITS OTHER THAN CLASS 2 (EDITION 6)

The requirements in UL 1012 have been developed to evaluate constant voltage power supplies (power supplies used in computers, stereo equipment and the like). They cover portable, stationary, and fixed power units having an input rating of 600 V or less, direct- and alternating- current, with at least one output not marked Class 2, and that are intended to be employed in ordinary locations in accordance with the National Electrical Code (ANSI/NFPA 70).

The requirements cover general purpose power supplies and power supplies for uses such as to supply some household appliances, school laboratories, cathodic protection equipment; power supply-battery charger combinations; and industrial equipment, including inverters, divided into two classes - those rated 10 kVA or less and those rated more than 10 kVA.

UL 1310 (1994) – USA: SAFETY STANDARD FOR CLASS 2 POWER UNITS (EDITION 4)

These requirements cover indoor and outdoor use Class 2 power supplies and battery chargers intended for use on alternating current branch circuits with a maximum potential of 150 V to ground. These requirements apply to:

- Portable and semi-permanent mounted direct plug-in units provided with 15 A blade configurations for use on nominal 120 or 240 V branch circuits;
- Cord- and plug-connected units provided with a 15 or 20 A attachment plug configuration; and
- Units permanently connected to the input supply.

1.2.4 OTHER SECTOR-SPECIFIC PROCEDURES FOR PRODUCT TESTING

Those documents and methods cannot be considered as official standards as official standardisation bodies have not adopted them. Nevertheless, e.g. the test method for calculating energy efficiency of EPS (see below) has been widely adopted by mandatory regulations and voluntary programs, and by industry.

[23] JIS C – Japanese Industrial Standard, Division C: Electronic & Electrical Engineering

1.2.4.1 Test method for calculating the energy efficiency of single-voltage external AC-DC and AC-AC power supplies (08/2004)

Issued by US EPA, for ENERGY STAR external power supplies (see Section 1.3.3.3), the test procedure has also been adopted by other voluntary programs:

- European Code of Conduct (Section 1.3.1.2), and
- Chinese CECP (Section 1.3.3.3),

as well as mandatory standards:

- California Standards for EPS (see Section 1.3.3.2), and
- Australian/New Zealand Minimum Energy Performance Standards (Section 1.3.3.1) – Standard AS/NZS 4665.1: Test method and energy performance mark

Scope: Product specific

The document specifies a test method for calculating the energy efficiency of EPS across a full range of load conditions.

The life cycle phase which is the concern of the procedure: Use phase

Box 1-2 outlines the test method in some detail. Power supplies with multiple, simultaneous output voltages and DC-DC voltage conversion equipment are not included in the scope of the method.

The procedure is not intended to replace IEC/EN 62301 standard (Section 1.2.1.1), which focuses closely on the measurement of standby power, but to augment and extend it downward to the measurement of no load conditions and upward to the measurement of active mode conditions. In relation to IEEE 1515-2000 (Section 1.2.2.1), it adds specificity regarding loading conditions and reporting requirements.

Box 1-2 – Test method: Energy efficiency of EPS

General Measurement Conditions: General conditions concerning measuring equipment, test room and test voltage as in IEC/EN 62301. The input voltage source shall be capable of delivering at least 10 times the rated[24] input power of the Unit Under Test (UUT).

Measurement Approach

Power supplies that are packed for consumer use to power a product must be tested with the output cord supplied by the manufacturer. The rated output current is used to determine the four active mode and the no load conditions required by this test procedure:

24 The original document uses the wording 'nameplate' input/output power.

Load Condition	Percentage of Rated Output Current
1	100 % ± 2%
2	75 % ± 2%
3	50 % ± 2%
4	25 ± 2%
5	0%

Loading Guideline

In order to load the power supply to produce all four active mode load conditions, a set of variable resistive or electronic loads shall be used. They need not be measured precisely with an ohmmeter.

Testing Sequence

The UUT shall be operated at 100% of rated output current for at least 30 minutes immediately prior to conducting efficiency measurements. After this warm-up period, the ac input power shall me monitored for a period of 5 minutes to assess the stability of UUT. If the power level does not drift more than 5% from the observed maximum value (considered stable), measurement can be recorded at the end of the 5 minute period. Subsequent load conditions (in sequence from condition 1 to 5 as indicated in the table above) can then be measured under the same 5 minute stability guidelines. Only one warm-up period of 30 minutes is required at the beginning of the test procedure.

If ac input power is not stable over a 5 minute period, the guidelines established by IEC/EN 62301 for measuring average power or accumulated energy over time shall be followed.

Efficiency calculation

Efficiency at a given load condition (n) is calculated as follows:

$$\text{Efficiency}_n = \frac{\text{Measured Active Output Power}_n}{\text{Measured Active AC Input Power}_n}$$

Average efficiency is calculated and reported as the arithmetic mean of the efficiency values calculated at load conditions 1 - 5. This simple arithmetic average of active mode efficiency values is not intended to represent weighted average efficiency, which would vary according to the duty cycle of the product power by the UUT.

Power consumption calculation

Power consumption of the UUT at each load condition 1 – 4 is simply the difference between the Active output power (W) and the AC active input power (W) at that load condition. For load condition 5 (no load) the power consumption is equal to the AC active input power (W) at that load condition.

The environmental aspect of the product that can be impacted by the procedure: Energy consumption of the product

The application of this procedure will influence the energy efficiency of the product.

1.2.4.2 TEST METHOD FOR DETERMINING THE ENERGY PERFORMANCE OF BATTERY CHARGING SYSTEMS (12/2005)

Scope: Product specific

Developed by US EPA for evaluating the compliance with the ENERGY STAR battery charger specifications (see Section 1.3.3.3), the methodology specifies a "test procedure for determining the Energy Ratio (ratio of energy used to maintain a battery and operate a charger, normalised to stored battery energy) of devices that charge and maintain secondary batteries." The document applies to the testing of a range of products such as power tools, small household appliances, floor care products, flashlights, and other devices using battery charger systems (BCS) with chargers input power being from 2 to 300 watts. Box 1-3 outlines the test method in some detail.

Note: EPS that fit the definition contained in ENERGY STAR program requirements for external power supplies are not covered by this procedure, even if they are primarily used to charge a battery. The test method above (Section 1.2.4.1) should be used, instead.

Box 1-3 – Test methodology for Battery Chargers

Testing Conditions:

- The power supply (from which the unit under test, UUT, derives its operating energy for the test) shall provide stable voltage at nominal +/- 1% with total harmonic content less than 2% (as specified in IEC/EN 62301). The crest factor of the voltage waveform must be between 1.34 and 1.49.[25]
- The abovementioned power supply shall provide stable output power at a frequency of nominal +/- 1%.
- Air speed shall be <0.5 m/s and ambient temperature shall be maintained at 23 +/- 5 °C.
- Both the UUT and the battery shall be new products. The battery(ies) shall have experienced no more than 5 complete charge/discharge cycles prior to testing.

[25] = The peak value of the test voltage shall be within 1.34 and 1.49 times its rms values.

Determining BCS Energy Ratio

Note: The document contains two discrete testing procedures: an abbreviated and full test methodology. The abbreviated test method may be conducted in cases where the UUT's energy consumption in both maintenance and standby modes does not vary significantly over time. Here only the full test method is outlines since it is to be applied always in cases of dispute/verification. We have also left out the special cases of multi voltage and multi-port chargers, which are covered by the standard.

Testing shall commence with a fully discharged battery, consistent with the following end of discharge voltages:

Nickel-based (NiCD/NiMh)	1.0 V/cell (IEC 61951)
Lead Acid (all types)	1.75 V/cell
All Others	Follow manufacturer specifications

1. Charge battery with the UUT for the period specified by the UUT manufacturer as the time needed to fully charge the battery under test. If no charge time is specified, the battery(ies) is to be charged for a period of at least 24 hours.
2. At the end of this period; begin measurement of energy used by UUT for battery maintenance mode. Continue measurement for a period f 36 hours (+/- 1 minute). Energy use may be measured either as a time series integral of power of as an accumulated watt-hour total.
3. Remove battery from charger and continue measurement of standby power for 12 hours (+/- 1 minute).
   Note: For some type of cord/cordless products, the charging circuitry is contained within the device itself and the only detachable part of the system is an AC power cord. In this case, the standby power/energy is zero. This does not apply to cradle products with a separable cord, as the cradle may still draw some power when the device/battery is removed.
4. Add the accumulated energy values obtained for the two periods to calculate the non-active energy use for the period.

Exceptions and specials cases:

- For 'multi-voltage a la carte chargers' (capable of charging different voltage batteries) the test procedure must be repeated using three batteries of different voltage, including the batteries with both the highest and lowest nominal battery energy.
- For 'multi-port chargers' the maximum number of identical batteries the charger can accommodate must be used for the test in place of a single battery.
- For chargers with batteries charged in series, the voltage of batteries is treated as a single battery with a voltage equal to the sum of all batteries in series.

Measuring Battery Energy

Measurement of battery energy shall be conducted according to IEC 61951-1 for nickel-cadmium cells, IEC 61951-2 for NiMH or IEC 61960 for lithium cells. For other cell chemistries, measurement shall be conducted according to an equivalent, industry accepted standard.

The battery shall be charged, according to the above section. After charging, it shall be stored in 20 ± 5℃ for not less than 1 hour and not more than 4 hours. The battery shall be discharged in the same temperature at a rate of 0.2C (C is the rated Ampere-hour capacity of the battery). The test shall continue until the battery pack reaches its end of discharge voltage (see table above).

During this period, voltage shall be logged, integrated at the end of discharge, and multiplied by the discharge rate to obtain battery energy. Te test may be repeated a maximum of 5 times, as in IEC 61951, with the best result taken as the final value.

Calculating Energy Ratio

Energy Ratio (ER) is calculated with the following equations:

Type of charger	Equation for ER	Reference Voltage (V)
Normal (Single battery)	$ER = \frac{\text{Nonactive Energy}}{\text{Battery Energy}}$	$V = V_{Battery}$
Multi-voltage a la carte	$ER = \frac{\sum \text{Nonactive Energies}}{\sum \text{Battery Energies}}$	$V = V_{Average}$*
Multi-port	$ER = \frac{\text{Nonactive Energy}}{\sum \text{Battery Energies}}$	$V = V_{Single\ Pack}$*
* Voltage of Batteries in series shall be treated as a single battery with a voltage equal to the sum of all batteries in series for all analysis.		

The life cycle phase which is the concern of the procedure: Use phase

The procedure is dedicated to the measurement of energy consumption for the use phase of the equipment.

The environmental aspect of the product that can be impacted by the procedure: Energy consumption of the product through improved energy efficiency.

1.2.4.3 ENERGY EFFICIENCY BATTERY CHARGER SYSTEM TEST PROCEDURE

California Energy Commission (CEC) who has set mandatory energy efficiency standards for EPS (see Section 1.3.3.2) is also funding the development of a generalised test procedure to measure the efficiency of all residential and commercial battery charger systems, through its Public Interest Energy Research (PIER) program.

The Draft 2 of the Procedure was published the 28th of February 2006 and comments to it were requested by the 15th of May 2006. Future updates and developments related to the test procedure are available at www.efficientproducts.org/bchargers/.

Scope: Product specific

The scope of the CEC Test Procedure is meant to cover battery charger systems that operate on single-phase voltage and have a nameplate ac rating of up to 2 kW. Its scope is thus wider than that of the above mentioned ENERGY STAR test method for battery chargers (chargers with input power from 2 to 300 watts).

"Battery charger system" is understood to include devices that are designed to run on battery power during part or all of their duty cycle (e.g. many portable devices) as well as battery systems primarily designed for electrical and emergency backup (e.g. small scale UPS systems).

The life cycle phase which is the concern of the procedure: Use phase

The procedure is dedicated to the measurement of energy consumption for the use phase of the equipment.

The test procedure includes three different tests:

- Battery discharge energy test – to measure the extractable energy from the battery associated with the battery charger system.
- Charge mode and Battery maintenance mode test – to measure the energy consumed during one charge and a significant portion of the maintenance cycle of the unit under test.
- No-battery mode test – to measure the energy consumed energy consumed when the battery is not attached (this test applies only to devices that have a battery charger system from which the battery itself or a component housing the battery can be readily removed from the charger during normal operation while charger remains connected to ac line voltage).

The environmental aspect of the product that can be impacted by the procedure: Energy consumption of the product through improved energy efficiency.

1.3. EXISTING LEGISLATION

In this section, environmental and other directives relevant to Lot 7 are identified. In addition, relevant legislation at Member State level, as well as in Third Countries (extra-EU) are dealt with. Voluntary agreements and already existing eco-design standards of the sector are also identified.

1.3.1 LEGISLATION AND AGREEMENTS AT EUROPEAN COMMUNITY LEVEL

1.3.1.1 EU LEGISLATION

There is no European Directive specific to battery chargers / EPS. Thus, there is no legislation concerning energy efficiency or consumption. Against this legislative situation, the most environmentally relevant policy measures are the WEEE and RoHS Directives. Among the generic European Directives that apply to electrical and electronic equipment, the most relevant to power supplies are the Low voltage, General product safety and Electromagnetic compatibility Directives. The later three Directives are all based on the principles of the so-called "New Approach", prescribing essential requirements, the voluntary use of standards, and conformity assessment procedures to be applied in order to apply the CE marking[26]. The above-mentioned Directives are shortly described below.

DIRECTIVE 2002/96/EC ON WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE)[27]

The directive applies to the categories of electrical and electronic equipment which are dependent on electric currents or electromagnetic fields in order to work properly and equipments for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex 1-1 and designed for use with a voltage rating not exceeding 1000 Volt for alternating current and 1500 Volt for direct current.

The scope of the directive covers also components, subassemblies and consumables, which are part of the product at the time of discarding. For this reason, EPS and chargers are impacted by this regulation.

Effective 13 August 2005, the directive requires the separate collection of electrical and electronic waste.

DIRECTIVE 2002/95/EC ON THE RESTRICTION OF THE USE OF CERTAIN HAZARDOUS SUBSTANCES IN ELECTRICAL AND ELECTRONIC EQUIPMENT (ROHS)[28]

The directive applies to the categories of electrical and electronic equipment that are covered by the WEEE directive at the exception of Medical devices and

26 http://europa.eu.int/comm/enterprise/electr_equipment/index_en.htm (download 15-08-2005)
27 Official Journal L 37, 13/02/2003, p. 24-39
28 Official Journal L 37, 13/02/2003, p. 19-23

Monitoring and control instruments. The RoHS directive does not directly apply to components or sub-assemblies. Moreover, EPS of chargers are not mentioned in the indicative list of product categories. This is the reason why it could be considered that RoHS Directive does not cover the EPS and chargers. However, in order to allow the compliance of IT equipments, tools or households appliances, EPS and chargers must be designed respecting the prescriptions of the RoHS directive.

The directive requires the substitution of various heavy metals (lead, mercury, cadmium, and hexavalent chromium) and brominated flame retardants (polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)) in new electrical and electronic equipment put on the market from 1 July 2006.

Low Voltage Directive (LVD) 73/23/EEC

The directive applies to all electrical equipment designed for use with a voltage rating[29] 50 – 1000 V ac and 75 – 1500 V dc. It requires products to have protection against hazards that could arise from within the product itself or from external influences. All risks arising from the use of electrical equipment, including mechanical, chemical, and all other risks. Noise and vibration, and ergonomic aspects, which could cause hazards, are also within the scope of the directive.

The directive dates back to 1973 and after thirty years, it has been decided that the text of LVD “needs to be modernised and provided with the flexibility to deal with new risks that were not foreseen at the time of its adoption”. Work is ongoing at the Commission to develop a proposal. A consultation of stakeholders concerning a possible amendment of the directive was closed in October 2005.[30]

General Product Safety Directive (GPSD) 2001/95/EC

The applicability of the safety requirements of this directive is limited only to those products for which safety provisions of EU law (e.g. other directives) are not available. Thus, concerning electrical equipment, this directive deals only goods that are not covered by the LVD.

The directive requires producers to place only safe products on the market, and to inform about risks. It obliges Member States to survey products on the market.

Electromagnetic Compatibility (EMC) Directive 89/336/EEC, amended by Directive 92/31/EEC

The directive lays down requirements in order to ensure that an apparatus is compatible with its electromagnetic environment (covering frequency band 0 to

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29 Voltage ratings refer to the voltage of the electrical input or output, not to voltages, which may appear inside the equipment.

30 http://ec.europa.eu/comm/enterprise/electr_equipment/lv/index.htm

400 GHz). I.e. that it functions as intended without disturbing other equipment and without being disturbed by other equipment. Equipment must be designed to minimise any potential electromagnetic interference with other equipment and also must itself be immune to specific levels of interference.

The directive will be replaced as from 20 July 2007 by the new Directive 2004/108/EC on the approximation of the Laws of Member States relating to electromagnetic compatibility, published in the OJEU on 31 December 2004 (L 390/24).

1.3.1.2 EU VOLUNTARY AGREEMENTS

CODE OF CONDUCT, VERSION 2 (24 NOVEMBER 2004)

Prepared by the European Commission in consultation with the stakeholders, the Code of Conduct concerns single voltage external ac-dc and ac-ac power supplies for electronic and electrical appliances, including among others AC adapters, battery chargers for mobile phones, domestic appliances, power tools and IT equipment, in the output power range 0.3W to 150W. Following EPS are exempted from the agreement: AC Adapter with more than 1 output terminal using switching power circuit; and contactless charger using switching power circuit.

The Code of Conduct aims at minimising energy consumption of EPS both under no-load and load conditions. Thus, signatories of the Code of Conduct commit themselves to achieve both the no-load power consumption and on-mode efficiency targets (see Table 1-3 and Table 1-4), for at least 80% of products for phase 1 (1.1.2005 – 31.12.2006), and 90% for phase 2[31] (1.1.2007 onwards) for the new models introduced on the market after the indicated date.

Table 1-3 – No-load Power Consumption Targets under Code of Conduct

Rated Output Power	No-load power consumption	
	Phase 1	Phase 2
0.3 ≤ W < 15	0.30 W	0.30 W
15 ≤ W < 50	0.50 W	0.30 W
50 ≤ W < 60	0.75 W	0.30 W
60 ≤ W < 150	1.00 W	0.50 W

The European Commission has proposed to all companies producing or buying EPS to sign this Code of Conduct. Signatories will report on a yearly basis in a confidential manner to the EC how many models of EPS out of the total number

[31] The external power supplies not meeting the Code of Conduct specifications shall not in any case exceed 10% of the total sales volume for all models (falling in the scope of the Code of Conduct) produced or purchased by a participating company.

of models a manufacturer produces reach the target in that year. In 2004, 10 companies fulfilled the reporting requirements: in total they reported 96 models, 56% of which were complying with the Code of Conduct requirements.[32] In 2005, there were 8 reporting companies: 92% of the reported 130 models complied with the requirements.[33] In May 2006, 21 companies were listed at the Code of Conduct internet site as signatories.[34]

Table 1-4 – Energy-Efficiency Criteria for Active Mode in Code of Conduct

<table>
<tr><th colspan="2">Phase 1

(for the period 1.1.2005 - 31.12 2006)</th><th colspan="2">Phase 2 (valid after 1.1.2007)</th></tr>
<tr><th>Rated Output Power</th><th>Energy-Efficiency in Active mode* (%)</th><th>Rated Output Power</th><th>Energy-Efficiency in Active mode* (expressed as decimal)</th></tr>
<tr><td>0 ≤ W < 1.5</td><td>30</td><td>0 < W ≤ 1</td><td>≥ 0.49 × P_{no}</td></tr>
<tr><td>1.5 ≤ W < 2.5</td><td>40</td><td rowspan="5">1 < W ≤ 49</td><td rowspan="5">≥ [0.09 × Ln(P_{no})]+ 0.49</td></tr>
<tr><td>2.5 ≤ W < 4.5</td><td>50</td></tr>
<tr><td>4.5 ≤ W < 6.0</td><td>60</td></tr>
<tr><td>6 ≤ W < 10</td><td>70</td></tr>
<tr><td>10 ≤ W < 25</td><td>75</td></tr>
<tr><td>25 ≤ W < 150</td><td>80</td><td>49 < W ≤ 150</td><td>≥ 0.84</td></tr>
<tr><td colspan="4">* On-mode efficiency is to be measured at 100% load (i.e. full rated output current) OR declared as the simple arithmetic average of efficiency measurements made at 25%, 50%, 75% and 100% of full rated output current.</td></tr>
</table>

EUROPEAN ECO-LABEL

European Eco-labelling scheme, while not having specifications for EPS/BC as individual products, has set requirements for them as part of the associated appliances. Following specification defines requirements for EPS:

- Portable Computers

  The criteria for eco-labelled portable computers[35] specify that their EPS "shall have a maximum consumption of no more than 0.75 W when it is connected to the electricity supply but is not connected to the computer".

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32 Siderius, H-P. Results of CoC for 2004. Presentation at the meeting of the CoC working group 25 May 2005, DG JRC, Ispra, Italy.

33 Siderius, H-P. Results of CoC for 2005. Presentation at the meeting of the CoC working group 08 March 2006, DG JRC, Ispra, Italy.

34 http://energyefficiency.jrc.cec.eu.int/html/s_b-ParticipantsCoC.htm

35 http://ec.europa.eu/environment/ecolabel/product/pg_portablecomputers_en.htm

It should be mentioned that by June 2006, there were no labelled products in this category.

GEEA LABEL / BENCHMARKS

GEEA (Group for Energy Efficient Appliances) is a forum of representatives from European national energy agencies and government departments (Austria, Denmark, Finland, France, Germany, the Netherlands, Sweden and Switzerland) working with industry on voluntary information activities in the field of energy efficient home electronics, office equipment and IT-equipment.

To allow the consumer to make an informed choice, a recognisable label was launched. However, the GEEA labelling scheme has not been very attractive to manufacturers, most likely reason being that other more widely known schemes such as ENERGY STAR exist. However, the GEEA criteria have been attractive to national authorities as a way to set national benchmarks. The criteria are revised regularly and GEEA aims at setting the "label" criteria so as to indicate that "appliance has a high energy-efficiency profile, only reached by approximately 25% of the most efficient models on the market". Thus the current and future goal of GEEA is to "effectively contribute to the establishment of a uniform European-wide scheme on voluntary informative activities" rather than promoting an alternative labelling scheme. Each GEEA Member is to implement informative campaigns according to the characteristics of its consumer market.

GEEA has set "label" criteria for three product groups directly relevant to this study:

- **EPS/BC for Portable Personal Equipment** i.e. equipment which can run on batteries and is sold with a charger or EPS
- **Wall Packs**, sold as separate product
- **Battery Chargers**, sold as separate product.

Table 1-5 presents the criteria for these groups. It should be noted that there are no products in these categories with a GEEA label and maybe there never will be, for the above mentioned reasons.

Table 1-5 – GEEA "labelling" / benchmarking criteria

Product category		**2005**	**2006**
EPS/BC for Portable personal equipment	No-load mode	0,3 W	0,1 W
Wall packs		0,3 W	0,1 W
Battery chargers	No-load mode	0,3 W	-

1.3.2 LEGISLATION AT MEMBER STATE LEVEL

1.3.2.1 MEMBER STATE LEGISLATION

No specific regulation has been identified at Member State level.

1.3.2.2 MEMBER STATE VOLUNTARY AGREEMENTS

GERMANY: BLUE ANGEL (RAL-UZ 106)

The Blue Angel eco-label is to signal the buyer that, compared with other products, the one bearing the environmental label takes precautionary consumer protection into account and has more favourable health and environmental properties.

The scheme does not have specifications for EPS/BC as individual products, but it sets requirements for them as part of the specifications of the associated appliances:

- Portable Computers

  The revised criteria for these products specify that “appropriate EPS must meet the requirements of the European Commission Code of Conduct on Efficiency of EPS (see section 1.3.1.2)”[36].

- Mobile phones

  Mobile phones are covered by the scheme and there are specifications for the appliances on the whole. However, these specifications do not set specific requirements for EPS/BC.

It should be mentioned that by June 2006, there were no labelled products in these categories.

NORDIC COUNTRIES: NORDIC SWAN

The Swan is the official Nordic eco-label, introduced by the Nordic Council of Ministers (Norway, Denmark, Iceland, Finland and Sweden). As the European Eco-label and the German Blue Angel, the scheme does not have specifications for EPS/BC as individual products. However, the following specification is relevant in this context:

- **Portable Computers**

  The EPS of “the portable computer shall have a maximum consumption of no more than 0.75 W when it is connected to the electricity supply but is not connected to the computer.”[37]

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36 RAL (2006) Basic Criteria for Award of the Environmental Label – Computers (RAL-UZ 78, edition June 2006)

37 Swan labelling of Personal computers, version 4.1 (10 June 2005 – 18 June 2008)

1.3.3 THIRD COUNTRY LEGISLATION

In recent years, State of California and Australia/New Zealand have developed mandatory standards on energy efficiency of EPS. Other US States are in the process of setting standards. United States has also started a process for developing federal EPS efficiency standards over the next five years.

These EPS legislations are based on the approach and basic efficiency levels of the voluntary ENERGY STAR labelling program, which will be the topic of the Section 1.3.3.3. In this section other third country and international voluntary agreements on energy efficiency of EPS and BC are identified.

1.3.3.1 LEGISLATION IN AUSTRALIA/NEW ZEALAND

AUSTRALIA AND NEW ZEALAND: MEPS (MINIMUM ENERGY PERFORMANCE STANDARDS) FOR EPS

According to the latest information[38], from 1st April 2008, most EPS with a nameplate DC output power rating up to 250 Watts, manufactured or imported for sale in Australia or New Zealand will be required to meet or exceed the average energy efficiency levels as provided in the Minimum Energy Performance Standards (AS/NZS 4665.2-2005). The requirements are technically identical to the ENERGY STAR criteria (see Section 1.3.3.3). In addition to the mandatory requirements, the standards define voluntary requirements for a 'high efficiency' product; they are identical to the Phase 2 requirements of the CEC standards (see Table 1-7).

The requirement and ability for AC-AC external power supplies to meet both no load and efficiency criteria is currently being analysed.[38]

The energy performance standard is associated with a test standard "AS/NZS 4665.1-2005: Test method and energy performance mark", which has been adopted from the test method outlined in Section 1.2.4.1.

Australian and New Zealand governments strongly encourage manufacturers and suppliers to mark products in accordance with the International Marking Protocol (see Section 1.3.3.5), however this is not yet mandatory.

AUSTRALIA AND NEW ZEALAND: MEPS (MINIMUM ENERGY PERFORMANCE STANDARDS) FOR HALOGEN LIGHTING TRANSFORMERS

Currently MEPS for extra low voltage tungsten halogen lighting transformers, which can be considered as EPS, are under consideration in Australia/New Zealand. A full background report with MEPS proposal was released in April 2005. The proposed minimum and high efficiency levels are summarised in Table 1-6.

38 FACT SHEET: Australian and New Zealand Energy Performance Requirements for External Power Supplies, December 2006, available at http://www.energyrating.gov.au/library/pubs/2006-factsheet-eps.pdf (viewed 22/01/2007)

Table 1-6 - Proposed MEPS for halogen lighting transformers (Australia and New Zealand)

Rated transformer power	MEPS level (% efficiency)	High efficiency level (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200 VA	≥ 91%	≥ 92.5%

The high efficiency level will be used as the preliminary phase 2 MEPS level, likely to commence not earlier than 2010. It also serves as eligibility criteria for Energy Allstars, which is a database and website[39] that identifies the most energy efficient products (top 10-25%) sold in Australia. To date, no lighting products are listed.

There are currently no suitable international test methods for energy efficiency of low voltage halogen lighting transformers. A Standards Australia working group has been established to draft a suitable test standard, based on the Australian Standard for EPS (see Section 1.2.3.1).[40]

1.3.3.2 LEGISLATION IN UNITED STATES AND CANADA

CALIFORNIA STANDARDS FOR EPS

On December 15, 2004, the California Energy Commission (CEC) adopted mandatory efficiency requirements for external power supplies sold in California which were amended in December 2006[41]. The general definitions and the efficiency requirements for the Phase 1 are identical to those of the ENERGY STAR (see Section1.3.3.4). The Phase 1 standards became effective January 1, 2007, for EPS used with laptop computers, mobile phones, printers, print servers, scanners, personal digital assistants (PDAs), and digital cameras. For EPS used with wireline telephones and all other applications, the effective date is July 1, 2007.

In addition, the CEC has already specified requirements for the Phase 2, which are to become effective July 1, 2008. The phase 2 requirements are shown in Table 1-7 for both active and no-load modes. Each power supply shall be marked on its nameplate with the appropriate numeral according to the International Marking Protocol (see Section 1.3.3.5).

The CEC has adopted the test method outlined in Section 1.2.4.1, to be used in energy efficiency testing.

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39 http://energyallstars.gov.au/products/index.html

40 NAEEEP (2005) MEPS – Halogen lighting transformers. Report no. 2005:13. Available at: http://www.energyrating.gov.au/library/details200513-mepshalogentrans.html

41 California Energy Commission (2006) Appliance Efficiency Regulations, (California Code of Regulations, Title 20, Sections 1601 through 1608), available at http://www.energy.ca.gov/appliances/2006regulations/index.html (viewed 18/01/2007)

Table 1-7 – California standards (Phase 2) for EPS for active and no-load modes

Phase 2 (01/07/2008 –)			
Rated Output Power (P_{no}) (in watts)	**Minimum Efficiency in Active Mode* (expressed as decimal)**	**Rated Output Power (P_{no}) (in watts)**	**Maximum Energy Consumption in No-Load Mode (in watts)**
$0 < P_{no} \leq 1$	$\geq 0.5 \times P_{no}$	$0 < P_{no} \leq 250$	0.5 W
$1 < P_{no} \leq 51$	$\geq [0.09 \times \mathrm{Ln}(P_{no})] + 0.5$		
$51 < P_{no} \leq 250$	0.85		

* Active mode efficiency is to be declared as the simple arithmetic average of efficiency measurements made at 25%, 50%, 75% and 100% of full rated output current.

P_{no} = rated output power (called 'nameplate output power' in the original document

OTHER STATE STANDARDS FOR EPS

Following the example of California, a number of other US States have recently developed appliance energy efficiency standards, including standards for 'single-voltage external power supplies'. Table 1-8 summarises the enacted EPS standards, as of July 2006, indicating the date of implementation (except California, see above).[42]

Table 1-8 – Implementation dates of State EPS energy efficiency standards (except California)

State	Implementation date
Arizona	01/2008
Massachusetts	01/2008
New York	*
Oregon	01/2007
Rhode Island	01/2008
Vermont	01/2008
Washington	01/2008

* For most products, the New York legislation requires the implementing agency to develop standards by June 30, 2006 and to implement such standards no sooner than six months after issuing final rules. The proceedings to develop these standards are currently underway.

42 http://www.standardsasap.org/06stateupdate.pdf

UNITED STATES APPLIANCE EFFICIENCY STANDARDS

On January 31, 2006, the US Department of Energy (DOE) released a schedule for setting new mandatory federal appliance efficiency standards over the next five years. Statutes require DOE to set "appliance standards at levels that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified." The plan provides for setting standards for Battery chargers and EPS, which are covered by Energy Policy Act of 2005 (EPACT 2005). The provisional goal of the standard seems to be to improve the efficiency of the current distribution of power supplies to a minimum of 80% efficiency.[43]

A number of new test procedures required by EPACT are to be issued, too.[44] According to the DOE schedule, test procedure should be finalised by August 2007. DOE must issue standards for EPS by August 2008, which are to be effective by August 2011. State EPS standards are not pre-empted until the federal standards go into effect.[42,44]

CANADIAN NATIONAL REQUIREMENTS FOR EPS

Canadian Standards Association (CSA) is preparing a Canadian national requirement for a single output EPS regarding minimum efficiency and no-load performance. Draft standard is to be established in 2007 and the mandatory compliance date is targeted for 2008.

1.3.3.3 LEGISLATION IN CHINA ENERGY CONSERVATION PROJECT (CECP)

Recently[45], based on the voluntary China Energy Conservation Project (CECP), China has set mandatory standards regarding the minimum allowable values of energy efficiency for single voltage external AC-DC and AC-AC power supplies (CSC/T30-2005). The CECP worked closely with ENERGY STAR in order to harmonise testing procedures and energy efficiency standards for EPS. Two years after the implementation date of this standard, the minimum allowable energy efficiency and maximum no-load consumption are those of ENERGY STAR, phase 1, requirements, however, during these two years the requirements are slightly lower.[46]

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43 DOE (2006) 2006 Schedule setting spreadsheets, available at: http://www.eere.energy.gov/buildings/appliance_standards/2006_schedule_setting.html

44 Source: http://www.eere.energy.gov/buildings/appliance_standards/2006_schedule_setting.html

45 WTO (2006) Notification G/TBT/CHN/236, 16 November 2006, English

46 General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (2006) Minimum allowable values of energy efficiency and evaluating values of energy conservation for single voltage external AC-DC and AC-AC power supplies (draft for approval), English version.

1.3.3.4 THIRD COUNTRY AND INTERNATIONAL VOLUNTARY AGREEMENTS

ENERGY STAR PROGRAM – EPS STANDARDS

ENERGY STAR© label

ENERGY STAR program initiated by US EPA was a pioneer in setting energy efficiency requirements for EPS. Manufacturers have been able to qualify and promote EPS as ENERGY STAR since 1 January 2005. As was seen above, California and Australia/New Zealand have adopted the ENERGY STAR requirements as mandatory standards. China is developing its voluntary specifications in accordance with ENERGY STAR.

The voluntary ENERGY STAR program specifies program requirements and eligibility criteria for single voltage external ac-dc and ac-ac power supplies whose rated output power is less than or equal to 250 watts.

The definition of an EPS is in line with the definition used for this study.[47]

The specification includes efficiency requirements for active mode, as well as maximum standby/no-load levels during the use phase. The label fixes limit values to respect: the minimum energy efficiency in active mode and the maximum energy consumption in no-load mode.

An individual model can only be qualified under one ENERGY STAR specification, i.e., EPS or battery charging system, (see the following sub-section) that best reflects the power supply and product design.

Since January 2005, it has been possible to qualify and promote EPS as ENERGY STAR. In order to qualify as ENERGY STAR, an EPS must meet or exceed a minimum average efficiency for active mode, which varies based on the model's rated output power[48] (Table 1-9); and comply with the no-load power requirement, which specifies the maximum ac power that may be used by a qualifying EPS in the no-load condition (Table 1-10).

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[47] ENERGY STAR Program Requirements for Single Voltage External AC-DC and AC-AC Power Supplies – Eligibility Criteria (Version 1.1), 03 March 2006.

[48] The Energy Star uses the term 'nameplate output power', but for the sake of clarity we have chosen to use the 'rated output power' (as in European Code of Conduct) throughout the document.

Table 1-9 – ENERGY STAR energy-efficiency criteria for active mode (Phase1)

Rated Output Power (P_{no}) (in watts)	Minimum Efficiency in Active Mode* (expressed as decimal)
$0 < P_{no} \leq 1$	$\geq 0.49 \times P_{no}$
$1 < P_{no} \leq 49$	$\geq [0.09 \times Ln(P_{no})] + 0.49$
$49 < P_{no} \leq 250$	≥ 0.84
* Active-mode efficiency is to be declared as the simple arithmetic average of efficiency testing at 25%, 50%, 75% and 100% of rated output current.	

Table 1-10 – ENERGY STAR energy consumption criteria for no load (Phase 1)

Rated Output Power (P_{no}) (in watts)	Maximum Energy Consumption in No-load Mode
$0 < P_{no} < 10$	≤ 0.5 W
$10 \leq P_{no} \leq 250$	≤ 0.75 W

To reflect the forthcoming improvements in technology, US EPA plans to implement phase 2 specifications on 1 January 2008. To this effect, EPA has already proposed phase 2 criteria for no-load energy consumption: 0.3 W (P_{no} less than 10 W) and 0.5 W (P_{no} from 10 to 250 W). Average active efficiency criteria are still to be determined.

ENERGY STAR partners shall follow the international efficiency marking protocol (Section 1.3.3.5) to indicate the energy performance of their ENERGY STAR qualified power supplies.

ENERGY STAR PROGRAM – STANDARDS FOR BATTERY CHARGERS

Since 1 January 2006, manufacturers have been able to qualify and promote battery charging systems as ENERGY STAR. The program specifies performance requirements for:

a) **Battery charging systems** packaged with portable, rechargeable products whose principal output is mechanical motion, light, the movement of air, or the production of heat (e.g., small home appliances, personal care products, power tools, flashlights, and floor care products);

b) **Stand-alone battery chargers** sold with products that use a detachable battery (e.g., some digital camera and camcorder designs); and

c) **Battery charging systems** intended to replace standard sized primary alkaline cells including: AAA, AA, C, D, 9-volt, etc. (i.e., universal battery chargers).

ENERGY STAR program does not cover:

- Inductively coupled devices used to transfer energy between two separate enclosures;
- Chargers with rated input power less than 2 watts and greater than 300 watts; and
- Charging systems that draw additional power to support added functionality such as radios, CD players, GFI AC outlets, and cleaning devices.

Three operational modes are defined for battery charging systems appliances:

- **Active Mode:** The condition in which the battery is receiving the main charge, equalizing cells, and performing other one-time or limited-time functions necessary for bringing the battery to the fully charged state.
- **Battery Maintenance Mode:** The condition in which the battery is still connected to the charger, but has been fully charged. This mode may persist for an indefinite period of time.
- **Standby (No-Load) Mode (IEC 62301, Section 2.1.1.1):** Lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

ENERGY STAR program focuses on non-active modes (i.e., battery maintenance and standby) because they offer significant potential for energy savings and can be consistently measured through a robust and easy-to-use test method (see Section 1.2.4.2). While a total energy approach including active mode has the benefit of addressing all operational modes, it also would require more complex usage scenarios/assumptions per product area.

To be eligible for ENERGY STAR qualification, a battery charging system must not exceed a maximum non-active energy ratio, which is based on the nominal battery voltage (Vb). Energy ratios for common battery voltages are shown in Table 1-11. For intermediate voltages, the battery charging system must not exceed the maximum Energy Ratio associated with the next highest voltage represented in the table.

Table 1-11 – Energy performance criteria (expressed as maximum non-active Energy Ratio, ER) for common battery voltages

Vb	**1.2**	**2.4**	**3.6**	**4.8**	**6.0**	**7.2**	**8.4**	**9.6**	**10.8**	**12.0**
ER	20.0	16.9	13.7	11.6	9.6	7.5	7.0	6.5	6.1	5.6
Vb	**13.2**	**14.4**	**15.6**	**16.8**	**18.0**	**19.2**	**20.4**	**21.6**	**22.8**	**≥24.0**
ER	5.1	4.5	4.3	4.2	3.8	3.6	3.5	3.3	3.2	3.0
Vb = Nominal battery voltage										

Korean e-Standby Program

The voluntary Energy-saving Office equipments & Home Electronic Appliances Program (e-Standby Program) has been implemented in the Republic of Korea since April 1, 1999. The program, operated by Ministry of Commerce, Industry and Energy (MOCIE) and Korea Energy Management Corporation (KEMCO) is aimed at reducing the standby power consumption.

External power supplies up to the rated input of 100 W, and battery chargers for mobile/cordless phones are included in the program. In public procurement, the Korean government gives preference to commodities produced using clean technologies.[49]

For external power supplies (up to 100 W), the standard sets a maximum no-load limit of 0.8 Watts. For battery chargers for mobile/cordless phones the maximum no-load limit was 1 W up until 31 December 2005, and will be 0.5 W from 1 July 2006 onwards.[50]

According to a stakeholder comment, for EPS, active mode minimum efficiency specifications similar to the ENERGY STAR levels were added to the standard in 2006.[51]

Consumers can identify the energy saving products by the Energy Boy endorsement label (energy-saving label) on the pertinent products (see Figure 1-4).

Figure 1-4 – Energy Boy label for Korean e-standby program

Japanese Top Runner program

In the Top Runner Program the energy performances of the most efficient products supplied domestically are used to set up the next efficiency standards. This best practice approach is implemented by the Japanese Ministry for Economic Trade and Industry (METI, formerly MITI) in accordance with the Japan's Law Concerning the Rational Use of Energy. Products included in the program and of relevance (albeit indirect) to EPS, are laptop computers.

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49 OECD/IEA (2002) Energy Policies of IEA Countries – The Republic of Korea 2002 Review

50 Korea Energy Management Corporation - KEMCO: http://www.kemco.or.kr/english/sub03_energyefficiency02.asp

51 Stakeholder comment from R. Fassler, Power Integrations, 14/12/2006

However, the Top Runner standards do not impose minimum energy performance standards for individual appliances. Japanese standards set a lower limit for the sales-weighted average efficiency of each manufacturer's shipment volumes by category per fiscal year. Stand-by consumption is included in the calculation of the energy-efficiency index for these appliances.

The advantage of the approach employed by the Top Runner program is its flexibility. It leaves more freedom to the manufacturer to adapt to the new regulation: they are free to keep energy consuming equipment on the market but they have to stimulate purchase of more energy-efficient equipment in order to meet the sales-weighted average efficiency target.

The Top Runner program is voluntary, but apparently in practice no manufacturer would risk negative publicity because it fails to achieve the standards.

JAPANESE ECO MARK PROGRAM

Eco Mark Program has been administered by the Japan Environment Association (JEA), since 1989, under the authority of the Japanese Environment Agency. The JEA develops environmental standards and permits compliant products to bear the Eco Mark symbol (Figure 1-5).

Figure 1-5 – Japanese Eco Mark

Eco Mark requirements (on standby) are currently limited to computers, printers and copiers. The requirements may indirectly apply to EPS as far as a computer or a printer is powered by external power supply.

- **Personal computers:** Maximum electricity consumption at off-mode of 2 W.
- **Printers:** Maximum electricity consumption at off-mode of 1 W.

1.3.3.5 INTERNATIONAL EFFICIENCY MARKING PROTOCOL FOR EPS

In 2005, an International Efficiency Marking Protocol for EPS was developed to create labelling scheme for identifying EPS's energy efficiency. As of 1 January 2005, the agencies that manage ENERGY STAR based programs had expressed their support to the protocol, i.e. US EPA, CEC, CECP and Australian Greenhouse Office (AGO). Product marking according to the protocol is mandatory under the CEC mandatory standards (section 1.3.3.2) and for the participants of the voluntary ENERGY STAR program (section 1.3.3.3). Australian authorities strongly encourage following the protocol, but despite the mandatory status of the energy performance standards (section 1.3.3.1), the efficiency marking is not mandatory at present. For China's CECP (Section 1.3.3.3) marking is also voluntary.

Figure 1-6 shows an illustration of the efficiency mark on an application. The mark, or efficiency indicator, is not intended to serve as a consumer information label, but to indicate the performance of the EPS when tested to the specific method.

The efficiency mark consists of Roman numeral (I – VII) and is to be printed on the power supply nameplate, as shown in Figure 1-6 below. "I" is the least stringent i.e. least efficient level, VII being the most efficient level. To date, levels I – V have been set, higher levels have been reserved for future use as more stringent levels are established.

Figure 1-6 – Illustration of International Efficiency Mark. The text "efficiency level" can be omitted.

Each efficiency level comprises both no-load and average efficiency[52] requirements. Table 1-12 provides the specific performance requirements for each efficiency level; the regulatory significance of each level is also mentioned.

Table 1-12 – Marks of the International Efficiency Marking Protocol: Energy performance requirements and regulatory significance

Mark	Performance Requirements				Regulatory Significance
	P_{no} (W)	No-Load Power (W)	P_{no} (W)	Average Efficiency (in decimals)	
I	None of the criteria below are met				

[52] Average efficiency is defined as the arithmetic average of efficiency measurements made at 25%, 50%, 75%, and 100% loading.

II	$0 < P_{no} \leq 10$	≤0.5	$0 < P_{no} \leq 1$	$\geq 0.39 \times P_{no}$	• China's CNIS: Proposed Phase 1 MEPS (mandatory)
	$10 < P_{no} \leq 60$	≤0.75	$1 < P_{no} \leq 49$	$\geq [0.107 \times Ln(P_{no})] + 0.39$	
	$60 < P_{no} \leq 250$	≤1.0	$49 < P_{no} \leq 250$	≥ 0.82	
III	$0 < P_{no} < 10$	≤0.5	$0 < P_{no} \leq 1$	$\geq 0.49 \times P_{no}$	• ENERGY STAR Phase 1 level – voluntary • CEC (CA) Phase 1 level – mandatory • AU&NZ MEPS – mandatory • CECP (China) level – voluntary
	$10 \leq P_{no} \leq 250$	≤0.75	$1 < P_{no} \leq 49$	$\geq [0.09 \times Ln(P_{no})] + 0.49$	
			$49 \leq P_{no} \leq 250$	≥ 0.84	
IV	$0 < P_{no} \leq 250$	≤0.5	$0 < P_{no} \leq 1$	$\geq 0.5 \times P_{no}$	• CEC (CA) Phase 2 level – mandatory • AU&NZ 'High efficiency' category – voluntary
			$1 < P_{no} \leq 51$	$\geq [0.09 \times Ln(P_{no})] + 0.5$	
			$51 \leq P_{no} \leq 250$	≥ 0.85	
V	Actual levels to be determined				• ENERGY STAR Phase 2 level (not established yet) – voluntary
VI and Higher	Reserved for future use.				
Where P_{no} is the Rated/Nameplate Output Power; and Ln refers to the natural logarithm.					

1.4. CONCLUSIONS

The discussion presented in Section 1.1 outlines the key issues and parameters regarding the products relevant to the lot 7. Further, it defines the scope of the study including the functional unit.

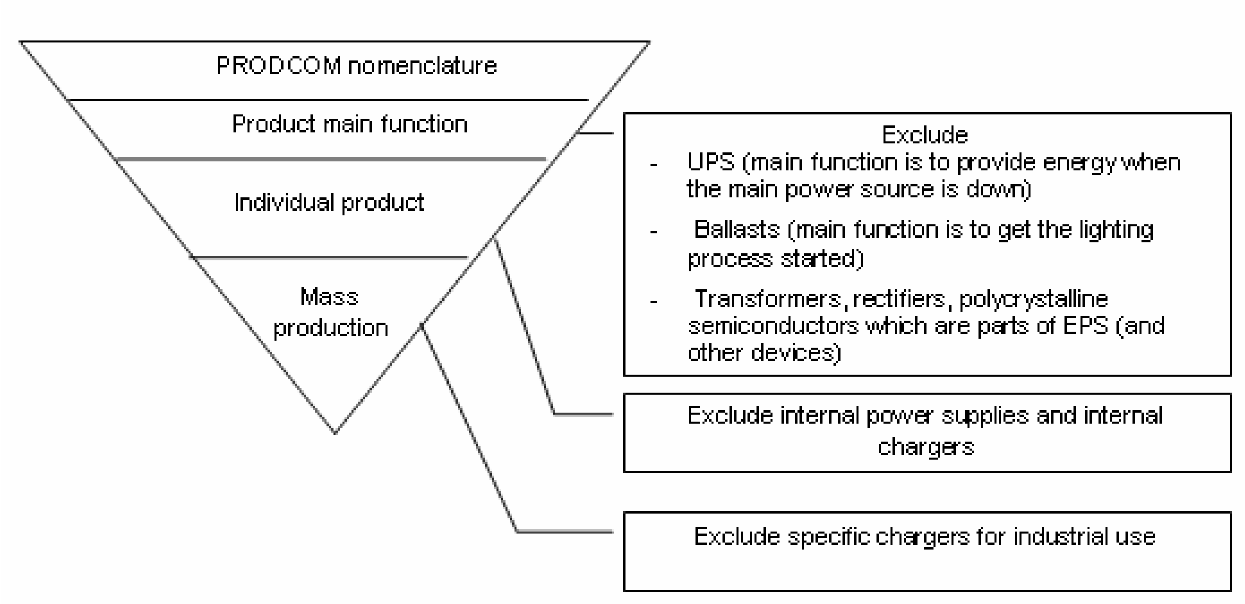
The identification of the relevant legislation worldwide reveals that Australia/New Zealand and some US States have already developed obligatory standards, but only for EPS. US federal standards for EPS are under development. In addition there are few other voluntary programs in the EU and in other countries.

Regarding EPS and battery charger product test standards, it can be concluded that there are no EN or ISO standards for the energy efficiency test methods. However, many existing mandatory or voluntary energy efficiency measures for EPS have adopted the same test method, originally developed for the purpose of the US EPA ENERGY STAR programme. This procedure is also well known by industry. There is also an ENERGY STAR test method for battery charging systems, which seems to be less well known. Those procedures could possibly be adopted in Europe for the measurement of energy efficiency performance of EPS or chargers.

ANNEX 1-1 – ANALYSIS OF THE RELEVANT PRODCOM CATEGORY

When considering the PRODCOM classification as a guide for product categorisation and scope definition, it has to be taken into account that PRODCOM classification is based partly at the component level and partly at the product level (e.g., a product marketed with a fixed external power supply unit most likely will not show up under the above mentioned PRODCOM classes at all – as most likely only the end-product category will be acknowledged as being relevant for classification). Consequently, PRODCOM could serve only as a rough orientation for the study. Figure 1-A1 illustrates the application of certain criteria to the PRODCOM category NACE 31.10 – "Manufacturing of electric motors, generators and transformers".

Figure 1-A1 – Selection criteria applied to PRODCOM category relevant to EPS and BC



The application of the above-presented criteria to the PRODCOM categories provides the following relevant categories for the lot 7, summarised in Table 1-A1.

Table 1-A1 – Relevant PRODCOM categories for lot 7

PRODCOM Category	**Remarks**
31.10.50.33 Accumulators chargers	Main chargers and EPS are in this category
31.10.50.40 Power supply units for telecommunication apparatus, automatic data-processing machines and units thereof	Within the scope, only if "external" and definition of EPS applies.
31.10.50.70 Static converters (excluding polycrystalline semiconductors, converters specially designed for welding, without welding equipment, accumulator chargers, rectifiers, inverters)	

All sub-categories of the potentially relevant PRODCOM classes are presented in the table below, and an explanation is provided when a category has been considered to fall outside the scope of this study.

PRODCOM Category	Falls under the scope of EuP lot 7?			Remarks
	Yes	partly	No	
31.10.41 Liquid dielectric transformers			×	It is a part of the public power supply infrastructure.
31.10.42 Other transformers, having a power handling capacity ≤ 16 kVA				
31.10.42.33 Measuring transformers having a power handling capacity ≤ 1 kVA (including for voltage measurement)			×	It is used for measuring and not for supplying the power.
31.10.42.35 Other transformers, nes, power handling capacity ≤ 1 kVA			×	It is only a component of an EPS.
31.10.42.53 Measuring transformers having a power handling capacity > 1 kVA but ≤ 16 kVA (including for voltage measurement)			×	It is used for measuring and not for supplying the power.
31.10.42.55 Other transformers, nes, 1 kVA < power handling capacity ≤ 16 kVA			×	Commonly used definitions (CoC / ENERGY STAR) not applicable, transformers for larger installations.
31.10.43 Other transformers, having a power handling capacity > 16 kVA			×	Commonly used definitions (CoC / ENERGY STAR) not applicable, transformers for larger installations

PRODCOM Category		Falls under the scope of EuP lot 7?			Remarks
31.10.50 Ballasts for discharge lamps or tubes; static converters; other inductors					
31.10.50.13	Inductors for discharge lamps or tubes			×	The function is not only to supply power as an EPS.
31.10.50.15	Ballasts for discharge lamps or tubes (excluding inductors)			×	The function is not only to supply power as an EPS.
31.10.50.23	Polycrystalline semiconductors			×	It could be used as a part of power supply but it is not an EPS.
31.10.50.33	Accumulators chargers	×			Main chargers and EPS are in this category
31.10.50.35	Rectifiers			×	It is only a component of an EPS.
31.10.50.40	Power supply units for telecommunication apparatus, automatic data-processing machines and units thereof		×		Yes if “external” and definition of EPS applies.
31.10.50.53	Inverters having a power handling capacity ≤ 7.5 kVA			×	Inverter is another name for the Uninterruptible Power Supplies. EPS are part of UPS but UPS could not be considered as EPS.
31.10.50.55	Inverters having a power handling capacity > 7.5 kVA			×	Inverter is another name for the Uninterruptible Power Supplies. EPS are part of UPS but UPS could not be

PRODCOM Category		Falls under the scope of EuP lot 7?			Remarks
					considered as EPS.
31.10.50.70	Static converters (excluding polycrystalline semiconductors, converters specially designed for welding, without welding equipment, accumulator chargers, rectifiers, inverters)		(×)		Yes if "external" and definition of EPS applies.
31.10.50.80	Inductors (excluding induction coils, deflection coils for cathode-ray tubes, for discharge lamps and tubes)			×	It is only a component of an EPS.

ANNEX 1-2 – ELECTRICAL SAFETY STANDARDS

Organisation / Reference / Date	Title	Keywords / Description
EN 50178: 1997	Electronic equipment for use in power installations	Keywords: Electronic equipment and components, Electronic engineering, Electrical installations, Electric power systems, Electric power networks, Electrical equipment, Electrical safety, Safety devices, Safety measures, Power control (electric), Electric converter. **Battery chargers, EPS, Chargers/EPS for industry, medical.** This standard establishes the minimal requirements of design, manufacturing, protection against electrical shocks, tests and integration of electrical equipment in systems with power. Excluded equipment: accessories and electrical devices used for domestic or similar applications.
EN 61140: 2002	Protection against electric shock - Common aspects for installation and equipment	**Battery chargers, EPS, Chargers/EPS, UPS: generic standard** This standard has been prepared for installation, systems and equipment without a voltage limit. It contains: - fundamental rule of protection against electric shock - protective provisions (elements of protective measures) - for basic protection / for fault protection - enhanced protective provisions - protective measures - coordination of electrical equipment and of protective provisions within an electrical installation - special operating and servicing conditions.
EN 61558-1: 1997 +A1: 1998 +A2: 2003	Safety of power transformers, power supply units and similar. – Part 1: General requirements and tests	Keywords: Power transformers, Small-power transformers, Transformers, Electrical safety, Electric power systems, Electrical equipment, Isolating transformers, Safety isolating transformers, Alternating-current transformers, Single-phase transformers, Polyphase transformers. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard**

ANNEX 1-3 – PRODUCT (FAMILY) SPECIFIC EMC STANDARDS

Product (family) specific EMC standards that may apply to power supplies (especially non-EPS):

Organisation / Reference / Date	Title	Keywords / Description
EN 50130-4: 1995 +A1: 1998 +A2: 2003	Alarm systems. Part 4: Electromagnetic compatibility - Product family standard: Immunity requirements for components of fire, intruder and social alarm systems	**Battery chargers, EPS, Chargers/EPS for security:** Intruder alarm systems, Hold-up alarm systems, Fire detection and fire alarm systems, Social alarm systems, CCTV systems, for security applications, Access control systems, for security applications, Alarm transmission system. This standard applies to the components of several alarm systems, intended for use in and around buildings in residential, commercial, light industrial and industrial environments. The tests and severities to be used are the same for indoor and outdoor applications of fixed, movable and portable equipment.
EN 50131-6: 1998	Alarm systems. Intrusion systems. Part 6 - Power supplies	Keywords: Burglar alarms, Alarm systems, Warning devices, Safety devices, Safety measures, Crime prevention devices, Anti-burglar measures, Electric power systems, Electric cells, Security systems in buildings, Grades (quality), Instructions for use, etc. **Battery chargers, EPS, Chargers/EPS for security**
EN 55011: 1998 +A1: 1999 +A2: 2002	Industrial, scientific and medical (ISM) radio-frequency equipment - Radio disturbance characteristics; limits and methods of measurement	**Battery chargers and EPS for ISM radio frequency equipment** Electromagnetic radiation disturbance limits are developed for the purpose of protecting radio communication services and signal levels, as well as for taking frequency bands, signal levels, separation distances between the interfering and interfered equipment, desired signal ratio, etc. into account.

Organisation / Reference / Date	Title	Keywords / Description
EN 55014-1: 2000 +A1: 2001 +A2: 2002	Electromagnetic Compatibility - Requirements for household appliances, electric tools and similar apparatus Part 1: Emission	Concerns the conduction and the radiation of radio-frequency disturbances from appliances whose main functions are performed by motors and switching or regulating devices, unless the radio frequency energy is intentionally generated or intended for illumination. Includes such equipment as: household electrical appliances, electric tools, regulating controls using semiconductor devices, motor-driven electro-medical apparatus, electric toys, automatic dispensing machines as well as cinema or slide projectors.
EN 55014-2: 1997 + A1: 2001	Electromagnetic Compatibility - Requirements for household appliances, electric tools and similar apparatus Part 2 : Immunity	Deals with the electromagnetic immunity of appliances and similar apparatus for household and similar purposes that use electricity, as well as electric toys and electric tools, the rated voltage of the apparatus being not more than 250 V for single-phase apparatus to be connected to phase and neutral, and 480 V for other apparatus. It specifies the immunity requirements in relation to continuous and transient, conducted and radiated electromagnetic disturbances, including electrostatic discharges, for the above-mentioned apparatus. Apparatus may incorporate motors, heating elements or their combination, may contain electric or electronic circuitry, and may be powered by the mains, by batteries, or by any other electrical power source. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered.
EN 55022: 1999 +A1: 2000 +A2: 2003	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement	The intention of this standard is to establish uniform requirements for the radio disturbance level of the equipment contained in the scope, to fix limits of disturbance, to describe methods of measurement and to standardise operating conditions and interpretation of results.

Organisation / Reference / Date	Title	Keywords / Description
EN 61000-4-8: 1994	Electromagnetic compatibility (EMC). Testing and measurement techniques. Power frequency magnetic field immunity test. Basic EMC publication	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Field strength (electric), Electric field effects, Magnetic field effects, Electrical testing, Definitions, Test equipment, Inductance,. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard** This standard relates to the immunity requirements of equipment, only under operational conditions, to magnetic disturbances at power frequency related to: - residential and commercial locations, - industrial installation and power plants, - medium voltage and high voltage sub-stations. The standard defines: recommended test levels / test equipment / test set-up / test procedure
EN 61000-4-9: 1994	Electromagnetic compatibility (EMC). Testing and measurement techniques. Pulse magnetic field immunity test. Basic EMC publication	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Field strength (electric), Electric fields, Magnetic fields, Electrical testing, Definitions, Test equipment, Testing conditions, etc. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard** This standard relates to the immunity requirements of equipment, only under operational conditions, to pulse magnetic disturbances mainly related to: - industrial installation and power plants, - medium voltage and high voltage sub-stations. The standard defines: recommended test levels / test equipment / test set-up / test procedure

Organisation / Reference / Date	Title	Keywords / Description
EN 61000-6-1: 2001	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Noise (spurious signals), Radio disturbances, Electronic equipment and components, Electrical equipment, Low-voltage equipment. Battery chargers, EPS, Chargers/EPS, UPS: generic standard
EN 61000-6-2: 2001	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Industrial facilities, Electrical equipment, Electronic equipment and components, Radio disturbances, Radiofrequencies, Very-high frequency. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard**
EN 61000-6-3: 2001 +A11: 2004	Electromagnetic compatibility (EMC). Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Noise (spurious signals), Electrical equipment, Electronic equipment and components, Industrial, Commercial, Domestic, Performance, Signa. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard**
EN 61000-6-4: 2001	Electromagnetic compatibility (EMC). Part 6-4: Generic standards - Emission standard for industrial environments	Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic fields, Electric power system disturbances, Emission, Noise (spurious signals), Industrial, Electrical equipment, Electronic equipment and components. **Battery chargers, EPS, Chargers/EPS, UPS: generic standard**

2. ECONOMIC AND MARKET ANALYSIS

The purpose of this section is to present the economic and market analysis related to external power supplies (EPS) and battery chargers. The aim is, firstly, to place this product group within the total of EU industry and trade policy. Secondly, it provides market and cost inputs for the EU-wide environmental impact of the product group. Thirdly, it aims at providing insights in the latest market trends so as to indicate the market structures and ongoing trends in product design. This will be an input for the subsequent tasks such as improvement potential. Finally, practical data on consumer prices and rates is provided to be used later in the study in a Life Cycle Cost (LCC) calculation.

2.1. GENERIC ECONOMIC DATA

Ideally, official EU statistics on import, export and production of External power supplies and Battery chargers in the EU would be presented here, as to be coherent with official data used in EU industry and trade policy. However, official EU production and trade statistics do not provide useful data on neither EPS nor BC. PRODCOM, which is the system for the collection and dissemination of statistics on the production of manufactured goods in EU, does not even explicitly mention these products (see section 1.1.1). Thus official statistics do not provide data on the products falling into the scope of this study. Furthermore, as EPS and BC are often shipped and sold with an end product, a significant share of these products would probably not figure individually in the trade statistics even if there was suitable category for reporting.

2.2. MARKET AND STOCK DATA

2.2.1 CURRENT SALES

More than a billion external power supplies are sold globally each year[1]. Europe's EPS market presents almost a third of the global market with sales of 475 million units in 2005, according to Darnell Group.[2] However, important appliance groups falling into the scope of this study are not included in this figure, namely battery chargers for rechargeable consumer batteries (type AA/AAA) and external power supplies for low voltage halogen lamps.

Based on complementary research conducted by the study consortium and the market research obtained from Darnell Group, the current European EPS/BC

1 PG&E (2004) Analysis of Standards Options for Single-Voltage, External AC to DC Power Supplies – CASE Project. California.

2 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – European Market Forecasts (power paper). California, USA.

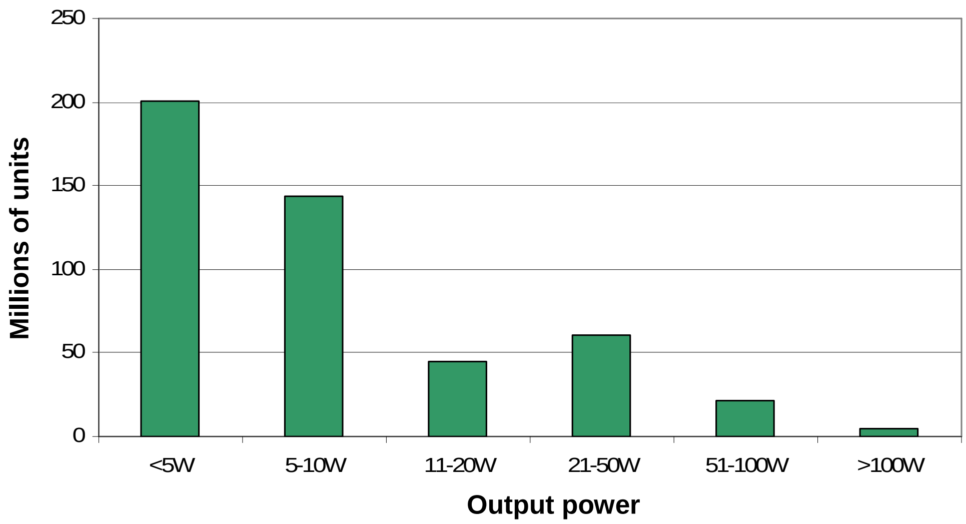
sales were estimated roughly at 526 million units per year in 2005. Even this figure is likely to be a conservative estimate[3].

Mobile phone EPS comprise the by far largest single category (52% in units) of the total market of external power supplies/battery chargers. Subsequently, in 2005, about 24% of total EPS sales on a unit basis in 2005 were linear power supplies.

2.2.1.1 SALES BY OUTPUT AND TECHNOLOGY

The lower wattage segments hold the bulk of the unit sales. The below 10 watt segment represents roughly 70% of the market (Figure 2-1). However, this segment accounts for only about 35% of revenue. Furthermore, low-powered EPSs are seeing somewhat slower growth, while the higher-wattage segments are driving the growth opportunities in this sector. This growth is led mainly by growing demand for high capacity notebook PCs.[2,13]

Figure 2-1 – Distribution of European sales by output rating category, 2005[2]



The share of linear and switch-mode technologies of the total sales has been rapidly changing in favour of the latter. According to Darnell Group, in 2005, about 24% of total EPS sales on a unit basis in 2005 were linear power supplies, rest being switch mode[4]. However, for certain products such as battery chargers linear technology is still more widely used.

2.2.1.2 SALES BY END-APPLICATION

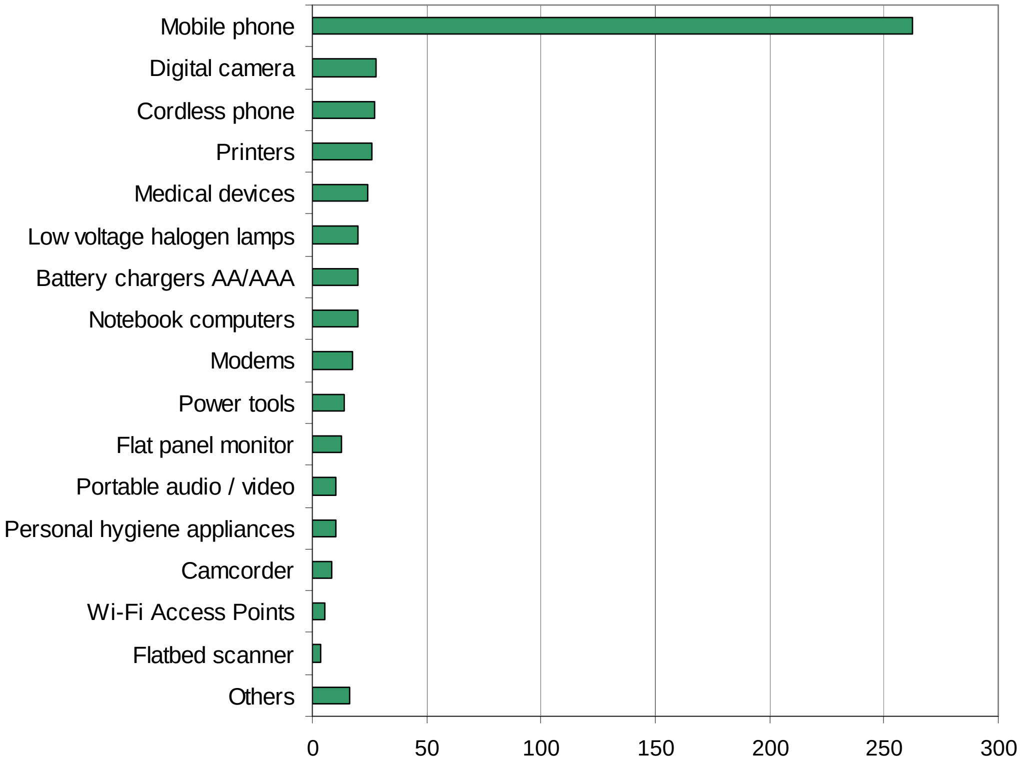
Figure 2-2 presents the current (2005) European EPS/BC sales of nearly 530 million units split by end-application. As already mentioned, mobile phone EPS

3 EuP Lot 7 stakeholder comment.

4 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – European Market Forecasts (power paper). California, USA.

comprise the by far largest single category (52% in units) of the total market of external power supplies/battery chargers. This explains, to a large extent, the high share of low wattage EPS of the total market (see above).

Figure 2-2 – Sales of EPS/BC in Europe, 2005



2.2.1.3 Replacement sales

A wide range of pricing and sales practices are observed in the replacement sales of EPS and BC though such sales are not very attractive because of prohibitive prices (see section 2.4.1). No systematic data on replacement sales was found, however, they can be estimated to be about 4-5% of total EPS sales.

2.2.2 Current stock

No existing studies were identified which would provide data on the European stock of EPS/BC. In such a case, from a methodological the point of view, the stock should be estimated by adding up the sales from previous years. However, as the statistics from previous years are also lacking, the current stock was estimated on the basis of current sales (discussed above) and the average economic lifetimes (see Section 3.2.1). This is likely to slightly overestimate the current stock as the EPS/BC sales have been annually growing in the past years. With these assumptions, the installed base, i.e. the stock was estimated at approximately 2080 million units for 2005 as shown in Table 2-1.

Table 2-1 – Application wise installed base of EPS/BC

Application	Sales (EU-25, 2005) [millions]	Lifetime [years]	Stock (EU-25, 2005) [millions]
Mobile phone and portable audio/video	273	3	819
Digital camera and camcorder	36	3	108
Printer and flat bed scanner	30	4	121
Cordless phone (incl. PBX)	30	6	180
Modems (incl. Set-top boxes/triple play; LAN equipment, Wi-Fi access points)	23	3	69
Laptop computers	20	5	99
Transformers for halogen lighting	20	10	200
Universal BC (AA/AAA NiMH)	20	5	100
Personal care appliance	10	4	40
Cordless power tools	14	5.5	77
Flat panel monitor	13	6	78
Other (incl. medical segment, professional two-way radios, etc.)	38	5	188
TOTAL	**526**		**2078**

COMPARISON WITH LITERATURE VALUES

Very few published sources present stock estimations for EPS/BC. Below the best known estimations are presented and compared to the estimated stock of this study. It is important to remember, that the literature values can only approximately be compared to the stock estimate of this study.

Some sources give estimates for the average numbers of EPS in a household. For the purpose of comparison with these values, the stock was divided by the number of households in EU-25 in 2005[5], which results in roughly 11 EPS per household. Regarding this figure, it should be remembered that it includes products in non-household environments and use (e.g. transformers for halogen lights are used also in offices and shops; 30% of power tools are estimated to be in professional use), so this “per household” value is expected to be higher than any result of household surveys or other sources regarding solely households.

The UK Market Transformation Programme (MTP) estimates that on average there are 5.3 EPS in a UK household. This includes EPS for portable audio, DECT and mobile phones, power tools, electric toothbrushes, etc., but excludes

5 Number of households (192.2 million households) derived from official statistics of the European Communities (http://epp.eurostat.ec.europa.eu)

EPS for laptops, lighting or other appliances considered explicitly by the MTP. Therefore this figure can clearly be regarded as an underestimate of the total number of EPS.

Based on an Australian household survey, the average Australian household has at least 5 appliances that are likely to have an EPS.[6] An intrusive Australian household survey in 2005 found on average 7 EPS per household.[7]

For U.S., it has been estimated that an average home contains 5–10 applications with an external power supply. Including commercial uses, the current stock has been estimated roughly at 1.3 billion EPS[8]. US EPA estimates the stock at approximately 1.5 billion power adapters[9]. This translates to approximately 5 EPS per American (2004) compared to 4.5 per European (EU-25, 2005) based on the stock estimate of this study.

It can be concluded that the estimated stock does not deviate significantly from the similar estimates in MS level or in other countries of roughly comparable socio-economic conditions.

2.2.3 PAST AND FUTURE STOCK

To this date, no comprehensive European stock models for the EPS/BC have been developed. As the official statistics are lacking for the products in question, there is no recorded data on past sales to support the assessment of sales and stock time series. The only feasible option is to derive past and future stock estimates based on the actual sales growth rates.

According to Darnell Group, from 2005 to 2010, the European market is projected to rise with a compound annual growth rate (CAGR) of about 9.4% in units.[10] An estimate of the stock for the Kyoto reference year of 1995 using this growth rate is likely to be inaccurate. However, the order of magnitude should be realistic, as overall the typical EPS/BC end-applications have seen significant growth over the past 10 years, and this growth is still continuing. There are many market trends that can affect the EPS/BC market either positively or negatively (see section 2.3.). Some end-applications are likely to reach market saturation and there is going to be more and more all-in-one type products (e.g. fusion of portable telephone, digital camera, and portable audio in one single product) and thus a reduction in the EPS/BC associated with these individual products, but on the other hand the new Member States are expected to provide greater new market opportunities to many of the end-appliances. The forecast past 2010, calculated with a CAGR of 5.0% in Table 2-2, is rather an indicative

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6 NAEEC (2004) Minimum Energy Performance Standards - External Power Supplies, report no. 2004/07

7 E3 (2006) 2005 Intrusive Residential Standby Survey Report. Australia. Pp 89, 92. (available at http://www.energyrating.gov.au/library/index.html#STANDBY)

8 PG&E (2004) Analysis of Standards Options for Single-Voltage, External AC to DC Power Supplies – CASE Project. California.

9 EPA (2005) Power Adapters Could Dramatically Reduce America's Electric Bill. Release date: 01/06/2005, EPA Newsroom (http://www.epa.gov/newsroom/)

10 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – European Market Forecasts (power paper). California, USA

figure and will depend on many external factors and the evolution of the products which is very difficult to imagine. If the current annual growth rate of 9.4% continues, the 2020 stock would be much larger than assumed.

Table 2-2 – Total installed base of EPS/BC for reference years, estimated on the basis of the 2005 stock

Reference year	1995		2005		2010		2020
CAGR (%)		9.4		9.4		5.0	
Stock (million units)	680		2080		2900		5000

Trends that shape the future EPS/BC market and stock, both quantitatively and qualitatively, are outlined below.

2.3. MARKET TRENDS

2.3.1 MARKET AND PRODUCTION STRUCTURE

EPS/BC market is only a sub-section of the total power supply market and many larger companies do not limit their activity to EPS/BC only. As the power supply market in general, the EPS market is ultra competitive and highly commoditised, outsourcing being the trend since long. Due to competitive situation pushing average price down, the compound annual growth rate for the EPS European market's revenue is projected to be over a percentage point lower than the growth in units (9.4%, see previous section) over the period of 2005-2010[11].

There are a number of major players in the market but nevertheless the industry in general remains fragmented with a large number of smaller companies, which typically concentrate on certain niches (either type and power range or OEM industry sector). For external AC-DC Power Supplies, the top ten companies account only for 41.3% of worldwide sales. Eight of the top-ten companies are headquartered in Asia with seven of the eight in Taiwan and mainland China[12]. Of the 27 main competitors on the EPS market included in the market research of Darnell[12], 5 are headquartered in EU.

2.3.2 GENERAL TRENDS IN PRODUCT DESIGN AND FEATURES

The market trends for external power supplies are either (EPS) technology driven or economy driven. Economy driven trends – from the view of the EPS manufacturer – either come from the supply side (material and component

11 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – European Market Forecasts (power paper). California, USA

12 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – Abstract, California

costs) or from the customer side (OEMs and indirectly consumers). Also, global regulations, end-application technology aspects, and aspects of competing power supply alternatives currently determine the overall trends for the external power supplies and chargers market. The largest drivers of external power supplies market are the sales and growth patterns of communications, computer and portable consumer electronics products[13].

Darnell[14] highlights the following as major market trends for ac-dc power supplies:

- Move towards digital power control and conversion, especially in ac-dc front ends for high-powered systems
- Growing need for power factor correction due to increasing wattage of many applications
- Regulation and economy driven importance of power supply efficiency.

The market trends are described in detail below.

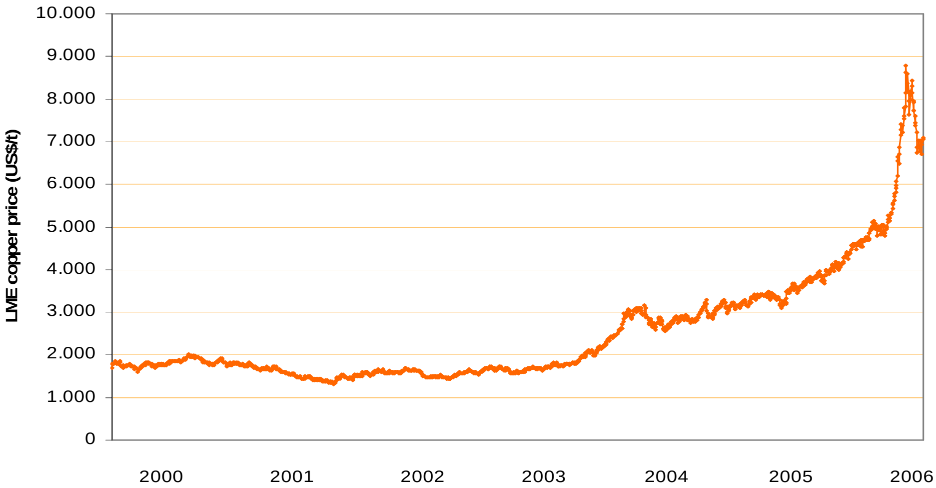
2.3.2.1 Economy driven trends: Materials costs

The changeover from linear to switched-mode power supplies is fostered currently by shifts in the general economic conditions, namely the dramatic price increase for raw materials: the higher the output power of an linear-mode EPS, the more material for the transformer coils (ferrite core and copper for windings), but also for the housing (due to larger transformers) is needed. These raw material costs are a significant part of the overall product costs. Therefore developments on the world raw materials markets for metals have a direct influence on product costs. See Figure 2-3 for copper price development since 2000.

13 Jeremiah Bryant (2005) External Power Supply Market Is a Mixed Bag (viewed 20/04/06 in http://www.psma.com/HTML/newsletter/Q3_2005/psma_update_2005-Q3.html#page9)

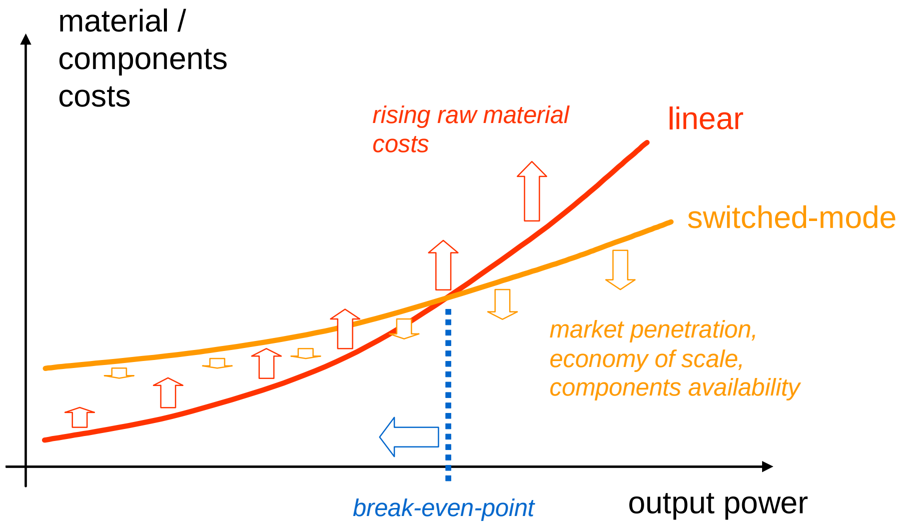
14 Darnell Group: AC-DC Power Supplies – Global Forecasts and Competitive Environment, 2006

Figure 2-3 - Copper price development January 2000 – June 2006
[London Metals Exchange data Source: http://www.metalsmarket.net, July 5, 2006]



In parallel, through effects of economy of scale and development and availability of components for switched-mode power supplies, the component costs for switched-mode designs decrease. As illustrated in Figure 2-4, there is a break-even point when linear transformers from the economic point of view become more costly than switched-mode power supplies. Currently, this break-even point is somewhere in the range of 15–20 W for most of the applications. For some applications such as mobile phones, this break even point can be even lower (3-4 W) because of mass scale production. As other aspects, such as the specification, number of units of an EPS type etc. have an influence on this break-even point as well, no universal wattage for this point can be given. However, the material and component costs trends mentioned above lead to a shift of this break-even point towards lower output power. This trend is stabile as market observers assume that raw material prices for the mid-term future will stay on a high level and might even increase further. Consequently, there is an economy driven trend favouring switched-mode power supply units.

Figure 2-4 - Material and components cost trends for linear and switched-mode power supply designs (not to scale)



Regarding the overall cost structure for EPS, most of the manufacturing of EPS is done in Asia (China and Taiwan). Even European manufacturers usually have their assembly facilities in Far East and only product development is still done in the EU.

2.3.2.2 Economy driven trends: End-application prices

External power supplies and chargers usually come just as a minor component of the end-appliance, usually not being a product differentiation criterion for the buyer. Further more, main business fields of EPS applications are under extreme price pressure, such as the ICT sector, the camera and power tools market. Consequently, this price pressure is passed from the OEMs to the EPS suppliers as well. EPS price is the major differentiation criterion for the OEMs.

End-application prices have significant effect on the trends of individually sold battery chargers for standard AA/AAA batteries. The prices of two important end-applications for these batteries, digital cameras and personal audio players, have come down rapidly in the past years. Subsequently, the consumers are not ready to pay high prices for a charger of these batteries. According to a BC manufacturer, consumer studies in various countries have shown that the speed of charging is not the determining factor at purchase for most consumers. Charging time of 4-5 hours, or even overnight, is considered sufficient. These charging times do not require complex technology, so the simple and cheap products satisfy the common consumer wishes. Consequently, battery chargers of the lowest price group represent 70% of the total sales volumes and experience the greatest market growth, according to the manufacturer.

2.3.2.3 REGULATION DRIVEN TRENDS[15]

Currently, regional energy efficiency requirements make it into the specification of products intended for the world market. Especially the Californian legislation[16] is mentioned by several manufacturers in the computer and mobile phone sector – being product categories sold worldwide usually – as being incorporated as requirement in specifications for external power supplies by OEMs.

Also the EU Code of Conduct and the ENERGY STAR are mentioned as trend setter for the whole EPS market. However, due to its binding character, the Californian regulation seems to have a larger impact. Mandatory standards in Australia/New Zealand and similar developments in a number of U.S. federal states are likely to enforce this trend.

Also the 2006 Power Technology Roadmap Workshop[17] identified as the two main drivers in the EPS business "energy concerns / need higher efficiency" and "external power supply efficiency standards on verge of being widely adopted in the United States".

2.3.2.4 END-APPLICATION DRIVEN TRENDS

Major end-application markets for external power supplies are increasing – some of them with tremendous growth rates – whereas others have reached market saturation.

End-applications with significant growth rates are:

- Home / office network equipment (modems, router, etc.)
- Mobile products (digital still cameras, video cameras, portable DVD players)
- Flat panel monitors
- Laptops.

According to IMS Research[18], it is the growing demand for external adapters in the consumer and notebook market, which pushes the ac-dc power supply market currently.

Darnell (Figure 2-5)[19] shows the forecasted worldwide power supply market until 2011 for sectors which might be relevant for power factor correction technologies – obviously, low-power markets, such as the mobile phone sector

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15 See section 1.3 for details on the regulations mentioned here.

16 California Code of Regulations, Title 20, Section 1605.3. State Standards for Non-Federally-Regulated Appliances

17 R. V. White, C. Mullett: 2006 Power Technology Roadmap Workshop, Dallas, Texas, March 18, 2006

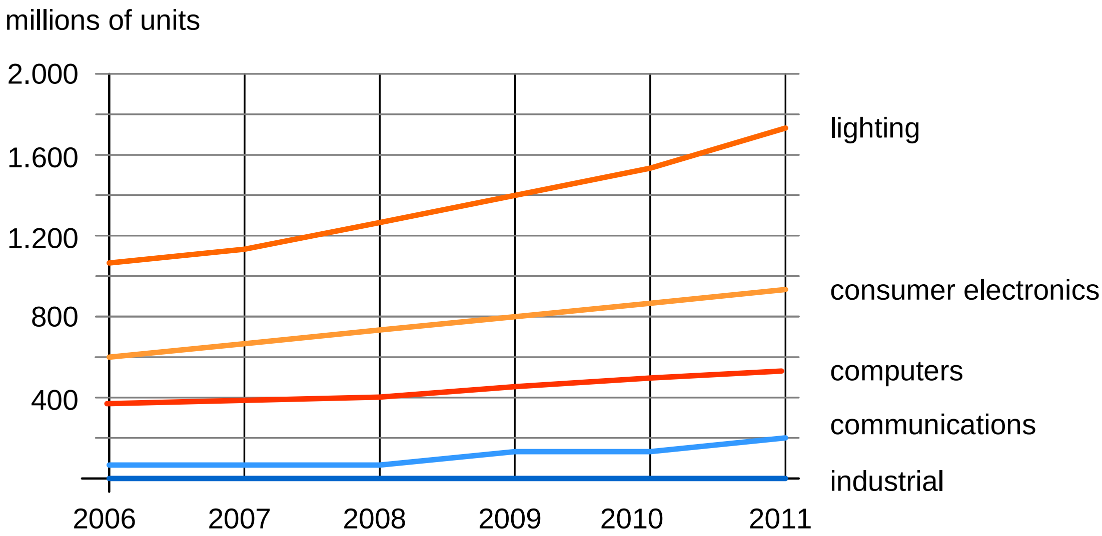
18 Ash Sharma (IMS Research): Delta Tightens Grip on Growing Power Supply Market, PSMA Newsletter, 2nd Quarter 2006

19 Darnell Group: Power Factor Correction – Potential Market Forecast, Application Trends & Competitive Environment, 2006

with annual sales of 825.5 million units in 2006[20] are not covered. There is no distinction between internal and external power supplies. However, some important trends can be given based on this data: The industrial sector plays a very minor role although there is high-power equipment covered. The computer sector sees an increase, which becomes even more important for the EPS market when acknowledging that there is a major shift from desktop computers with internal power supplies to laptops with external ones. Consumer electronics is a very important sector for power supplies, but most of them are internal ones except for mobile products and some peripheral equipment (e.g. set-top boxes).

According to the Darnell data, lighting is the dominating market for power supplies – even with a steady growth rate – but ballasts for fluorescent lamps (which are not covered in this product group study) are likely to be the most important product segment. In many countries the growth in low voltage halogen lamps, which require a transformer, has been very high in recent years and this trend may account for some of the future growth in lighting products. On the other hand, low voltage halogen lamps are increasingly replaced by 230V lamps that do not have a transformer[21], so it is hard to predict the result of these opposing trends.

Figure 2-5 - Worldwide power supply market (internal and external)



Further end-applications might be designed to work with external power supplies in the future, which have internal ones currently. Such an example is flat panel TV sets with a trend to thinner screens. For thermal and volume reasons, the power supplies for such kind of devices might be "outsourced" to EPS in the future.

20 IDC - Press Release: A Strong Fourth Quarter Sends Worldwide Mobile Phone Shipments over 800 Million Units for 2005, According to IDC, January 26, 2006

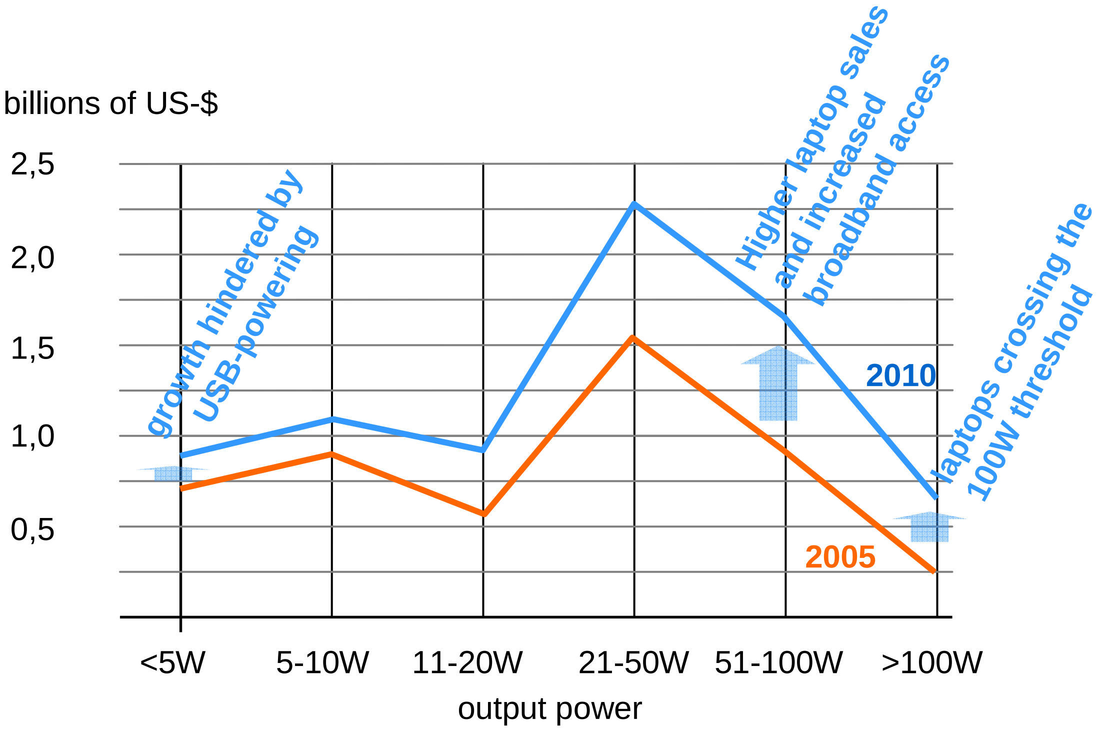
21 Personal communication with U. Mathies, Tridonic Atco (25 October 2006)

While further end-applications equipped with EPS together with the trend of increasing number of electric appliances per person/household would indicate the increase in EPS numbers, the current trend of **convergence** has an opposite effect. The most obvious example of convergence is that of consumer portable device converging into mobile phones. This development is currently most obvious for digital cameras: growing feature sets in camera phones are projected to crowd out digital camera sales (and associated EPS sales). This convergence trend does not just affect cameras, but also MP3 players and other consumer devices.[22]

Besides the market growth, the **power requirements of the end equipments change**: In the case of laptops, the power requirements in the recent past increased from the 50 to 70 W range to partly beyond 100 W – due to added functionalities and a trend towards increasing battery capacity -, whereas weight and size expectations have essentially remained the same[23]. Consequently, for the laptop EPS market segment, there is a need for increasing EPS efficiency as the EPS otherwise face very severe problems in thermal management.

In general, Darnell forecasts a growing market across all power ranges (see Figure 2-6)[24], but whereas the low-power range will see a moderate growth as USB-powered devices gain ground, the market will shift to high-powered segments, driven mainly by monitors and laptops.

Figure 2-6 - Global market for external power supplies in 2005 and 2010



22 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – Abstract, California.

23 Dhaval Dalal: Notebook Adapters Face Efficiency Challenge, Power Electronics Technology, April 2006, p.22

24 Based on [Jeremiah P. Bryant: Power Analyzer: External ac-dc Pushes Towards Higher Wattages, EDN Power Technology, March 2006, p. 14]

An alternative to external power supplies is **USB-powering**, where the end equipment, such as MP3 players are connected to and charged via a computer USB port. Consequently the computer as such serves as "external power supply" to the end equipment. Such a power supply system is very likely to change also the use patterns of a computer, which remains in on-mode just to charge the connected end equipment. An example is Apple's iPod™, which initially was powered by external power supplies and represented a significant part of the overall mobile audio market, but latest product generations of the iPod™ now rely solely on USB-powering at 2.5 W. The EPS market lost one of its fastest growing markets and Jeremiah P. Bryant, Analyst at Darnell Group[25], expects other portable audio makers to follow the Apple example.

Another alternative form of powering, competing with the low-wattage EPS, is **Power-over-Ethernet (PoE)**. Similar to the USB-powering, the power is delivered to networked devices over the data cable, without the need for a separate AC power connection/adaptor. PoE is specifically targeting applications such as Wi-Fi access points and fixed RFID readers. While PoE may make significant gains in these applications, they make up a small part of the overall external power supply market, and as such the overall impact to the EPS market is minimal[26].

As there is the requirement for a **power factor correction (PFC) stage for power supplies from 75W input upwards** due to IEC 61000-3-2 standard[27] (see also the Systems Analysis), this threshold fosters a trend to make external power supplies in this range more efficient to stay below this 75W input value. In fact, the laptop EPS are the first mass-market power supplies to fall in the scope of IEC 61000-3-2 [28]. Achievable is approximately a 65 W output EPS which stays below the 75 W input, meaning a trend for more efficient EPS in the 60W range: improved efficiency in this range is an economic incentive, as the PFC stage is avoided. On the other hand, this driver is relevant to this power range only.

Another aspect that influences the market for external power supplies is the **mobile society**: an EPS for notebooks should work anywhere in the world. Of minor relevance is the aspect of different plug systems in the different world regions, which has to be solved by the use of external adapters, but highly relevant are the different voltages and frequencies supplied: for user comfort, a voltage-switch is not appreciated to change from 110 V to 220 V, but the EPS has to be designed for universal line-voltage operation.

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25 J. P. Bryant: Portable Devices Drive Power Market, EDN Power Technology, March 2006, p. 8

26 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – Abstract, California.

27 IEC 61000-3-2: Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)

28 Dhaval Dalal: Notebook Adapters Face Efficiency Challenge, Power Electronics Technology, April 2006, p.23

Mobile society and **portable end-appliances** demand small EPS/BC, which is driving the market towards more efficient switched-mode technology (see also section 2.3.2.7).

There is a strong evolution in the **battery market**, driven mainly by the end-application developments. The application of the different battery types has an effect on the needed charging technology and this has a direct influence on the **battery chargers**:

- *NiCd batteries*, though a mature technology, are losing share in the portable household equipment market segment due to limited cycle life and inconvenience caused by the so-called memory effect (see section 4.4.3). Low energy density of NiCd batteries compared to other technologies makes NiCd less attractive for the mobile devices market. However, NiCd are gaining share in the high power range application market segment and is currently predominant in the cordless phone segment[29]. This will change very soon as portable NiCd batteries will be phased out in winter 2008 from most portable household applications and sales as individual portable cells. From September 26th, 2008, the new EU battery directive will restrict the sale of portable batteries and accumulators containing more than 0.002% of cadmium, except for emergency and alarm systems, medical equipment, and cordless power tools[30].
- *NiMH batteries* have gained market share from NiCd in recent years on the household equipment market, but face the migration of mobile phone manufacturers to Lithium based batteries.
- *Li-Ion batteries* are the fastest growing battery technology. Frost & Sullivan forecasts for 2009 a global market share of 78.8 in terms of units for mobile IT and communication devices[31]. Also some major OEMs in the power tool market now move over from Ni-based batteries to Li-based batteries as a result of increased power density of the Li-based chemistry achieved in the recent past. At the same time, the segment of Li-Ion and Li-Polymer battery manufacturers is undergoing a change with more diversification, resulting in dropping battery prices, making this technology even more attractive for portable devices[32].
- *Li-Polymer batteries* as a new technology is more expensive than Li-Ion, but mass market introduction will lead to falling prices, leading to better competitiveness of this technology.
- *Lead-acid batteries* serve a stable market segment of larger power applications where weight is of little concern. Their even lower energy density than that of NiCd batteries makes them the least attractive option for the mobile computing, communication and similar applications.

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29 Sara M. Bradford: Rechargeable Batteries – Keeping Pace with the Digital Age? Battery Power Products & Technology magazine, March 2004

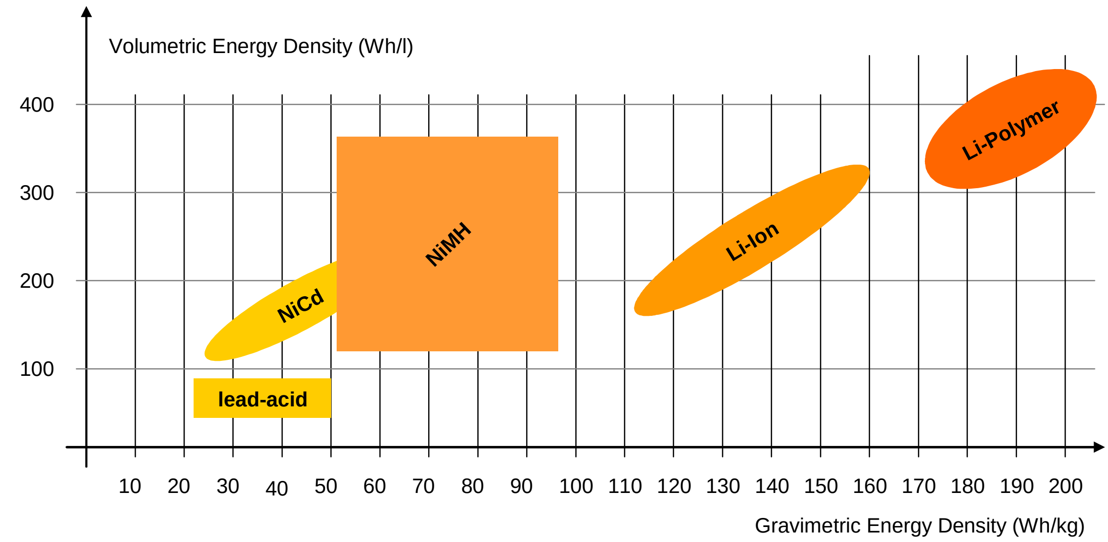
30 Directive of the European Parliament and of the Council on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC, approved on July 4, 2006, publication in OJ pending

31 Sara M. Bradford: Rechargeable Batteries – Keeping Pace with the Digital Age? Battery Power Products & Technology magazine, March 2004

32 J. P. Bryant: Portable Devices Drive Power Market, EDN Power Technology, March 2006, p. 8-10

Having in mind the trend towards increased capacity and power demand and light-weight products in many relevant charger market segments, the energy density of the different battery technologies gives a clear indication on technology trends (Figure 2-7[33]).

Figure 2-7 - Energy Densities of rechargeable battery technologies



2.3.2.5 Technology driven trends: Major research and development activities for EPS

The changing market environment as outlined in the chapter above results in R&D activities in the EPS sector to come up with improved products. However, for the power supply technology in general the "change in next 4-5 years [is] believed to be incremental – no revolutions, disruptions, quantum leaps seen in the technology"[34].

However, some technological developments lead to significant changes in the market, namely:

- *Synchronous power rectification*, providing enhanced efficiency and therefore a more compact power conversion, being originally a technology for the high-end market segment, is now entering the market of more price-sensitive applications[35]. However, synchronous power rectification is applied only in the > 100 W output range, being rather of interest for internal power supplies than for external ones.

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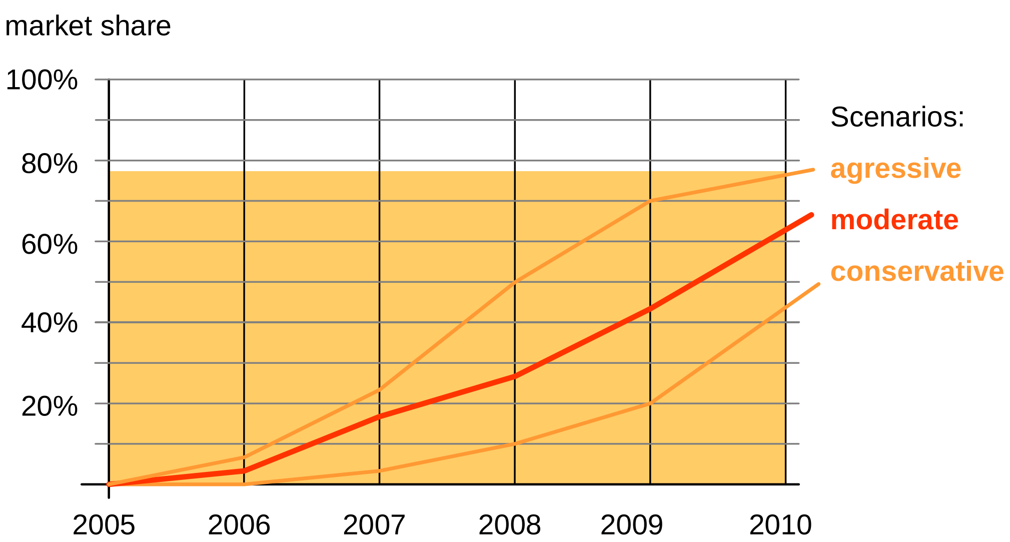
33 Based on [Harding Battery Handbook, Norton Shores, MI, 2004]

34 Robert V. White, Charles Mullett: 2006 Power Technology Roadmap Workshop, Dallas, Texas, March 18, 2006

35 Gary Bocock (Ed.): Power Supply Technical Guide, XP Power plc 2005

- *Digital power control* for EPS is expected to grow from less than 10% in terms of market share currently to 40-75% in 2010 according to a Darnell market report (see Figure 2-8) [36].

Figure 2-8 - Digital power control forecast for external ac-dc power supplies



Control and management approaches using digital circuits begin to gain favour in the power supply industry. Beyond reduced cost, digitalised power offers several advantages over conventional analogue approaches[37] :

- Ease of design and use
- Smaller form factor
- Lower power dissipation
- Flexibility in design, manufacturing, and modified operation
- Scalability and reusability.

2.3.2.6 Technology driven trends: Power supply system changes

There are technologies on the market and under development, which could replace external power supplies and/or batteries in the mid-term future to certain extend – mainly solar cells and fuel cells. However, only in the long run far beyond 2010 they might represent a really significant market share.

Furthermore, for small mobile devices there are concepts under development to use even other sources of energy (e.g. temperature differences, motion, etc.), but these concepts will rather open new field of application (sensor networks)

36 Darnell Group: Emerging Markets in Digital Power Electronics: Component, Converter and System-Level opportunities, 2005], referenced in: [Silicon Laboratories: Silicon Labs Enters the Power Market]

37 Christopher Ambarian (2006) Digital Power-Management ICs Will Hit $1.5 Billion By 2015, electronic design Online ID #11866, January 19.

than replace EPS applications. Dynamo chargers for mobile phones are on the market, but have to be seen rather as gadgets. Also laptops with crank handles have been developed – e.g. the 100$ laptop developed by the MIT -, but such powering sources target developing countries with limited access to mains supply and will rarely play a role for the EU market in the foreseeable future.

SOLAR CELL MARKET FOR MOBILE DEVICES

For several years now, there are solar chargers for mobile devices on the market. However, these products serve only a niche market as they are more expensive than EPS – which anyhow come with the product. Also prototypes of mobile phones with integrated photovoltaic cells have been developed, but have not see market introduction yet.

FUEL CELL MARKET FOR MOBILE DEVICES

Throughout the mid-term future, battery technology will continue to be the dominant energy storage technology. Especially low-cost – compared to the current status of fuel cell technology – and low-maintenance are the key benefits of batteries. However, prototypes of fuel cell powered laptops have been developed already a few years ago by NEC and Toshiba and for mobile phones Motorola researches the use of fuel cell technology[38]. Fuel cells for professional video cameras are already on the market for two years now, and the manufacturer Jadoo intends to go into the direction of the semi-professional market as well. In 2006 a small number of fuel cells is expected to enter the market as battery chargers[39]. This corresponds with a market report by NanoMarkets predicting from 2006 on a certain minor role for fuel cell technology for mobile applications, but it will be far from replacing batteries into the next decade[40]. Darnell even forecasts that fuel cells will remain less than 0.1% of the portable power packs market throughout at least 2010[41].

2.3.2.7 SHIFT FROM LINEAR TO SWITCHED-MODE POWER SUPPLIES

Currently we observe a shift from linear to switched-mode technology in external power supplies. This shift is driven by several of the above mentioned trends, specifically

- material and component cost issues, availability of mature components
- trend towards high power applications (a market segment, where linear power supplies do not play a role)
- global legislation and labelling activities
- mobile applications require miniaturised EPS.

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38 BBC news: Fuel cell laptop promises long life, June 30, 2003, http://news.bbc.co.uk/2/hi/technology/3031870.stm

39 J. P. Bryant: Portable Devices Drive Power Market, EDN Power Technology, March 2006, p. 10

40 Battery Technology Will Dominate Portable Power for Next Decade, Power Electronics Technology, November 2005

41 J. P. Bryant: Portable Devices Drive Power Market, EDN Power Technology, March 2006, p. 10

For the North American market, Darnell describes the development as follows[42]: from a market share of 54% in terms of units in 2000 the switched-mode technology increased to 75% (2005) and is predicted to reach 84% in 2010 with a remaining market share of 16% for linear power supplies. It is assumed that this market trend holds true also for the EU.

2.4. CONSUMER EXPENDITURE BASE DATA

2.4.1 AVERAGE CONSUMER PRICES

Only a minor share of the total sales of EPS and BC are sold directly to consumers as individual products – mostly to replace a broken or lost original product or to purchase a second product for the home/office. Usually, it is the OEM who originally purchases these products which are then further sold to the consumer as a part of an end-application. This market structure implies that it is very difficult to get information on the consumer prices of most products falling in the scope of this study.

EPS/DEDICATED BC SOLD AS A PART OF AN END-APPLIANCE

When EPS/BC is sold as an integral part of an end-appliance, the price of the product (EPS/BC) is not revealed. Data can be gathered on the business-to-business prices which the OEMs pay to the EPS/BC manufacturers. These prices, however, are considered confidential due to the extremely competitive business environment and most of the companies refused to reveal them for this study. Such data is available through specific market research reports.

However, the business-to-business prices cannot be taken for the consumer prices. Logistic costs, taxes, profit margin, etc., all add to the OEM price. Very roughly, the consumer prices of EPS/BC, as part of an end-appliance, are about three times the OEM prices.[43] Table 2-3 presents the estimated EPS/dedicated BC customer prices based on the factor-3 and market research from Darnell Group[44].

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42 Compilation in [TIAX LLC (2006) Assessment of Analyses Performed for the California Energy Efficiency Regulations for Consumer Electronics Products. Cambridge, MA, USA, February 2.]

43 EuP Lot 7 personal stakeholder communication.

44 Darnell Group Inc. (2005) External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment – European Market Forecasts (power paper). California, USA.

Table 2-3 – Estimated consumer prices for EPS/dedicated BC

Output power range	Type of end-appliance	Consumer price (€/unit)[45]
<10 W	Mobile phone, DECT phone, personal hygiene products	3.50
	Digital camera, set-top box	6.50
10-49 W	Power tool (DIY)	15.00
	Power tool (professional)	30.00
	Printer	12.50
>50 W	Laptop PC	30.00

Naturally, such a generalisation should be treated with caution, as the exact factor depends on the specific competitive situation, on the product type and number of other factors. Yet, for the purpose of the life cycle cost calculation, these prices should give a relevant order of magnitude for the purchase costs.

These prices show that when EPS/BC are sold as an integral part of the end-appliance, in relative terms, their price often represents only some percents of the final price of the end-application.

EPS/DEDICATED BC SOLD SEPARATELY

When EPS and dedicated BC are sold separately, it is often to replace a lost/damaged product or to buy a second product for home or office. When sold separately by the original end application manufacturer, these products often cost many times more than when their price is integrated with the end-appliance price. Typical retail prices vary from 15-100 euros; however prices up to 200 euros have been observed. There are some generic ones too which may be cheaper but not always compatible with all applications.

These separate sales can be considered a marginal part of the total sales and the retail prices of the individually sold units do not reflect the average of the total market.

TRANSFORMERS FOR HALOGEN LIGHTING

Transformers for halogen lighting are sometimes sold together with, for example, a set of spot lamps. However, a significant share of these products is sold individually and thus consumer prices exist. Based on a catalogue research, an average price for electronic transformers is around 20 euros for the common output range (35-105 VA). For magnetic (EI-core) transformers, the price depends on the output power; 20 euros being the average price for 60 VA transformer. Prices for toroidal transformers, which are a special type of

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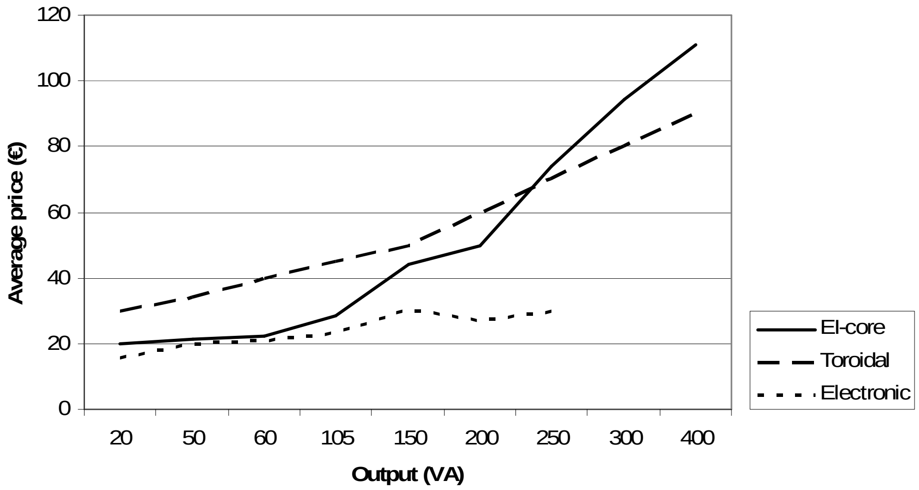
45 Average exchange rate (1.244) of 2005 from ECB (www.ecb.int/stats/) was used to convert the OEM dollar prices from Darnell market research to euros.

magnetic transformers, are somewhat higher for the common output power range (Figure 2-9). However, this technology presents only a minor share of the total transformer sales and hence these prices will not be taken into account.

Figure 2-9 – Average price of halogen lighting transformers by the output power



BC FOR STANDARD RECHARGEABLE BATTERIES

The chargers for rechargeable consumer batteries, most of which are currently NiMH AA/AAA batteries, are products that are marketed and sold as individually products to consumers. However, these chargers are seldom sold alone and are commonly bundled with 2-4 rechargeable batteries.

The prices for common household battery chargers start from less than 10 euros, but prices for more sophisticated products can be dozens of euros more. A look on the prices of some popular internet sales sites and a few comments from the BC manufacturers give the impression that the prices may have gone down even more since 2003, at least for the internet sales. Based on the 2003 Warentest survey[46], it was observed that an average consumer price for a **BC without a charging control** or a timer/thermal control go from as low as 5 till 25 euros while an average price for a **BC with microprocessor charging controls** range from 20 to 60 euros. For the calculations, an average price of **15 euros and 35 euros** is assumed respectively.

2.4.2 RATES FOR RUNNING COSTS AND DISPOSAL

The only significant running costs of an EPS or BC are the electricity costs. Electricity prices for households in Member States, as of July 1 2005, are presented in Table 2-4. These rates will be used in a Life Cycle Cost (LCC) calculation at the later stage of the study.

46 Stiftung Warentest (2003) Strom für den Strand – Akku-Ladegeräte Test. Available at: http://www.stiftung-warentest.de/online/alle/test/1102157/1102157/1102522.html

The batteries cannot be considered simply consumables for battery chargers but their lifetime and thus consumption may be affected by the characteristics of the charger. A charger with no or poor charging control may destroy the batteries prematurely and this may result in a higher number of bought and used batteries during the lifetime of a charger. Finally, this translates into higher costs during the use phase. In order to model the effect of different kinds of chargers on life cycle costs, a price of 12 euros per 4 AA batteries of an average capacity is assumed.

EPS/BC are hardly repaired or maintained, as it is normally cheaper to buy a replacement. Thus these costs are not relevant in this study.

Disposal of ESP/BC does not incur significant costs to a consumer. Under the Directive 2002/96/EC on WEEE[47] Directive, consumers can dispose of electric and electronic appliances without charge. Eventually, the costs of WEEE collection and treatment are likely to be integrated in the product prices, but as to the current situation, the disposal of existing stock of appliances is free to the consumer.

As the WEEE compliance systems are still at their early stage in many Member States, the final impacts regarding EPS/BC are yet unknown. Currently, the average operational WEEE collection and treatment costs for e.g. small household appliances and electronic tools are around 0.30 euros/kg[48]. Based on an average product weight, for a mobile phone EPS, this would mean an additional cost of 0.03 euros, while for a power tool charger the costs would be around 0.20 euros. However, the costs vary widely between Member States. Furthermore, costs are expected to decrease by time, e.g. due to expected economies of scale.

If the consumer disposes of EPS/BC as part of household waste, part of the general waste fees/taxes should theoretically be allocated to these products. However, due to their small size and infrequent disposal, these costs can be neglected.

Reflecting the current situation, as well as the unpredictability of the long term effects of the WEEE Directive, we assume zero disposal costs for the products falling into the scope of this study.

47 Waste electrical and electronic equipment

48 Bio Intelligence Service et al. (2006) Synthesis report: Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC). For DG ENV, European Commission

Table 2-4 – Electricity prices for household consumers (01/07/2005)[49]

Member State	Overall price (€ / 100 kWh)	Share of Taxes* (% of the overall price)
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)	9.36	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)	19.60	43.5
United Kingdom (UK)	9.26	4.9
EU-25 Average	13.60	23.8
* VAT and other taxes		
Note: EUROSTAT collects data every 6 months for five categories of household consumption, ranging between 600 kWh to 20000 kWh. This table refers to 'medium sized household' (annual consumption of 3500 kWh of which 1300 during night).		

49 Eurostat (04/2006) Electricity prices for households and industry on 1st July 2005. Statistics in focus – Environment and Energy

2.4.3 INTEREST AND INFLATION RATES

The following table shows national inflation and interest rates for the EU-25 as published by Eurostat and the European Central Bank (ECB).

Table 2-5 – Interest and inflation rates for EU-25

Member State	Inflation rate [(a)] (%)	Interest rate [(b)] (%)
Austria (AT)	1.6	3.4
Belgium (BE)	2.8	3.4
Cyprus (CY)	1.4	5.2
Czech Republic (CZ)	1.9	:
Denmark (DK)	2.2	3.4
Estonia (EE)	3.6	-
Finland (FI)	1.1	3.4
France (FR)	1.8	3.4
Germany (DE)	2.1	3.4
Greece (EL)	3.5	3.6
Hungary (HU)	3.3	6.6
Ireland (IE)	2.2	3.3
Italy (IT)	2.1	3.6
Latvia (LV)	7.1	3.5
Lithuania (LT)	3.0	3.7
Luxembourg (LU)	3.4	:
Malta (MT)	3.4	4.6
Poland (PL)	0.8	5.2
Portugal (PT)	2.5	3.4
Slovak Republic (SK)	3.9	3.5
Slovenia (SI)	2.4	3.8
Spain (ES)	3.7	3.4
Sweden (SE)	1.3	3.4
The Netherlands (NL)	2.1	3.4
United Kingdom (UK)	2.0	4.5
EU-15 Average	2.2 [(c)]	3.42 [(c)]
EU-25 Average	2.1	3.9

[(a)] Annual Inflation (%) in Dec 2005 Eurostat "Euro-Indicators", 7/2006 - 19 January 2006

[(b)] ECB long-term interest rates; 10-year government bond yields, secondary market. Annual average (%), 2005

[(c)] Euro zone

2.5. CONCLUSIONS

Establishing the stock of external power supplies and battery chargers through existing data sources proved to be difficult. Publicly available statistics hardly mention these products explicitly and no public European studies covering relevant market issues have been carried out.

In the absence of a single source for comprehensive market data, current sales and stock of EPS and BC were derived from different sources in sections 2.2.1 and 2.2.2, respectively. These figures may not be very accurate, but they show clearly that the yearly sales of the products are much higher than the 200000 unit threshold set in the EuP Directive.

3. CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

It may be possible to influence the consumer behaviour to some extent by product-design which consequently will influence the environmental impacts and the energy efficiency associated with the product during its use-phase. However, more importantly, consumer behaviour has a significant direct effect on the energy use of EPS and BC during their lifetime. The objective of this section is to explore the consumer behaviour and local infrastructure aspects for the lot 7 products and the manner in which these aspects can influence the energy and environmental performance of these products.

First, the focus will be on the real life efficiency of the EPS and BC. Consumer behaviour is a very relevant input for the assessment of the environmental impact and the life cycle costs of the products, and the relevant parameters will be quantified for the purpose of later analysis. Important parameters include frequency and characteristics of use, as well as real load efficiencies. Further, consumer behaviour related to the end-of-life aspects will be discussed.

EPS and BC, being relatively simple and small appliances, do not set particular requirements for the local physical infra-structure. However, the social and economic factors can introduce barriers and restrictions to possible eco-design measures for EuPs, which will be described in the last sub-section.

3.1. REAL LIFE EFFICIENCY

3.1.1 INTRODUCTION

User behaviour can have a major impact on the overall energy consumption of EPS/BC in the use phase. For example, a mobile phone charger which is left plugged in the grid will draw electricity even when the phone is fully charged and is not in use or when the equipment is not even connected to the charger. User's decision to unplug or not to unplug an EPS/BC after each use of the end-appliance or after charging, has a significant effect on the (unnecessary) energy consumption of these products. Especially so, because the efficiency of EPS/BC is often the poorest under low load conditions.

- **Operating modes of EPS**

As discussed in Task 1, EPS may be used to power a wide variety of devices. While many of these 'end-use' appliances may operate in different modes including passive and active stand-by, the situation is slightly different for external power supplies. Firstly, very few have an on/off switch and are therefore always **'on'** unless they are **'unplugged'**. When connected to the mains, they may operate in two modes: one **without the end-use appliance attached**, and one **with the end-use appliance attached and drawing load**. In the latter case, the load of the EPS is determined by the demand from the end-use appliance, rather than any setting within the power supply. In this case, the power supply may be supplying power to the end-use device at anything up to 100% of its rated power.[1]

The operating modes of halogen lighting transformers are rather different from other EPS. The power switch is normally placed on the primary side of the transformer, so there is no electricity consumption by the transformer when the lights are turned off. Therefore, no-load conditions or other use modes than 'on' and 'off' are not relevant.

Operating modes of BC

Operating modes of battery chargers are independent from the end-application. Similarly to EPS, they usually lack an on/off switch, so they are really off only when **'unplugged'**. They are said to be in **no-load** when connected to the mains, but not holding batteries. When batteries are inserted, the charger may operate in two modes: **charging mode** or **maintenance mode** (i.e. when batteries are fully charged). The time in charging mode is related to battery chemistry and the charging technology used. However, the time in no-load and maintenance mode are dependent on the user behaviour.

Time in different operating modes

The time spent in different modes of operation and loads is highly variable depending on the end-use appliance/application of the EPS/BC. The EPS for some rechargeable devices may be disconnected from the mains electricity supply when they are not charging the end-use appliance, however many people leave them on for convenience (e.g. laptops). Some end-use appliances are always on (e.g. answering machines, cordless phone) and their external power supplies operate continuously, most of the time under low load conditions. EPS for end-use appliances with an on/off switch that do not need to stay on all the time (e.g. computer speakers, external modems) are also often left on at the mains even when the appliance is switched off, and hence the power supply is operating at no-load levels.[1]

Energy use

In order to estimate energy use of EPS and BC, it is necessary to establish a duty cycle (i.e. load profile) that estimates the amount of time the power supply is expected to operate at each of the measured loading levels. These duty cycles vary widely according to the end-use appliance/application. Furthermore a duty cycle of a product depends significantly on the individual user. For example, a laptop of a travelling business man will have a very different duty cycle than a laptop used by a family for word processing and internet/e-mail use in the evenings.

Currently, there is very little knowledge on the usage patterns and duty cycles of the electrical and electronic appliances and current estimates of "average" duty

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[1] NAEEC (2004) Minimum Energy Performance Standards - External Power Supplies, report no. 2004/07

cycles can only be considered rough estimates. Substantial user-behaviour surveys and end use metering would be required to gain objective knowledge of typical duty cycles. The following sections present usage patterns and load profile (also called duty cycle) estimations based on the data gathered from the literature, EPS/BC manufacturers and from OEMs.

3.1.2 DUTY CYCLES FOR EPS FROM LITERATURE

Table 3-1 presents the estimated duty cycles that were used by the CASE project[2] to estimate the baseline EPS energy use for California. The source underlines that these can only be considered estimates, for the reasons explained above.

Table 3-1 – Estimated duty cycles by power supply wattage (Californian CASE project)

Output power (watts)	Fraction of time at load					
	Unplugged	No load	25% rated load	50% rated load	75% rated load	100% rated load
<2.5	35%	25%	20%	14%	5%	1%
2.5 - <4.5	20%	15%	20%	30%	14%	1%
4.5 - <6	30%	25%	20%	15%	9%	1%
6 - <10	10%	10%	24%	30%	25%	1%
10 - <24	10%	20%	28%	26%	15%	1%
>24	15%	15%	34%	25%	10%	1%

For some important EPS applications (e.g. EPS for mobile phones) the duty cycles in Table 3-1 do not seem to properly reflect a realistic usage pattern. Indeed, within an output power range, EPSs can have very different usage pattern and duty cycles depending on the end-use appliance.

Table 3-2 shows the approximate load profiles for EPS of typical end-appliances and two battery chargers, derived from end-application data of a German study[3]. These profiles can be considered as rough estimations only, since the modes of the end-appliances do not straightforwardly translate into operating modes of the EPS. Further, no reason is given for the difference between mobile phone charger and other battery chargers/stations, as to whether they are mostly unplugged on under no-load conditions.

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2 PG&E (2004) Analysis of Standards Options for Single-Voltage, External AC to DC Power Supplies – CASE Project. California.

3 BMWA (2005) Technical and legal application possibilities of the compulsory labelling of the standby consumption of electrical household and office appliances. Annex 2 of the English summary. Report of the Federal Ministry of Economics and Labour (BMWA), Germany.

Table 3-2 – Load profiles for EPS of typical end-appliances and BC (weighed average of household and office appliance profiles)

EPS for:	Time at load (h/day)					
	unplugged	no-load	25%	50%	75%	100%
DECT phone	-	-	-	23.5	-	0.5
Laptop computer	8.1	-	13.1	-	-	2.8
LCD screen	-	8.2	13.8	-	-	2.0
Inkjet printer	-	4.2	19.7	-	-	0.1
Scanner	-	5.9	18.0	-	-	0.1
ISDN-box	-	-	-	-	-	24.0
Mobile phone charger[1]	18.0	Data not provided				
Battery chargers/stations	-	23.5	-	-	-	0.5

[1] For the mobile phone charger, the mode of the remaining 6 hours/day was not specified.

Further, a report on an Australian intrusive household study[4] gives information on the mode in which some typical end-appliances were found in households (Table 3-3). It is difficult to evaluate the load profile of EPS based on such data on end-appliances. Furthermore, the share of unplugged appliances is likely to be higher over a period of 24 hours, as the survey was most probably carried out at daytime. But survey results reveal that majority of EPS were plugged in, while battery chargers were mostly unplugged.

Table 3-3 – The mode of typical end-appliances in households

	Share of appliances found in the respective mode			
	unplugged	off-mode	passive/ active stand-by	on
Notebook	46%	40%	12%	2%
LCD screen	9%	55%	36%	0%
Inkjet printer	27%	47%	26%	0%
Cordless drill	86%		14%	
Personal health & hygiene products[1]	~100%			
Modems	13%	5%	81%	
EPS	31%		69%	
Battery chargers/stations	72%		28%	

[1] shavers, hair appliances, rechargeable toothbrushes, etc.

4 E3 (2006) 2005 Intrusive Residential Standby Survey Report. Australia. Pp 89, 92. (available at http://www.energyrating.gov.au/library/index.html#STANDBY)

Comparison of the battery charger data in the above tables reveals the poor state of knowledge regarding the average user behaviour of EPS and BC. The decision to unplug a charger is dependent on the consumer and there are very few studies on this aspect.

As a further data source, manufacturers of typical end-appliances were consulted on the likely load profiles, which will be presented below. For this study, load profiles given by manufacturers were the preferred source for the calculation of the use phase energy consumption, as they were provided specifically for the EPS/BC, not for the end-appliance itself. An operating mode of an end-appliance does not directly translate into the mode and load of the EPS or a battery charger.

3.1.3 USAGE PATTERNS AND LOAD PROFILES FOR TYPICAL END-APPLICATIONS

3.1.3.1 LOW OUTPUT POWER RANGE (< 10 W)

MOBILE PHONES

Mobile phones are normally connected to the EPS only to charge the battery. Obviously, the mobile phone might not be disconnected from EPS immediately after the battery is fully charged, e.g. when charging during the night. The intensity of use affects the need to charge the phone and thus has an effect on the load profile. The no-load time is also very much dependent on the user's behaviour.

An Integrated Product Policy Pilot Project used two different user scenarios to model the LCA of a mobile phone (see Table 3-4).

Table 3-4 – User scenarios in a mobile phone LCA study[5]

Light user Scenario	Heavy user Scenario
Moderate use of several phone features	Heavy use of all phone features
Battery discharge 95%	Battery discharge 100%
Minimal charging of 1.5 hrs in every 48 hrs	Charging of 10 hrs in every 24 hrs
Charger left on even after the completion of charging	

The assumption, that the charger is left on continuously, seems like a worst-case estimate. This is confirmed by the data in Table 3-2 and Table 3-3. Furthermore, the above-mentioned scenarios reflect the two opposite levels of use (light and heavy users), whereas for the purpose of this study an average use profile is needed.

5 Nokia (2005) Integrated Product Policy Pilot Project – Stage 1 Final Report: Life Cycle Environmental Issues of Mobile Phones. Nokia, Espoo, Finland.

As an alternative to the above user scenarios, Table 3-5 presents the average load profile for a mobile phone, estimated by two EPS/BC manufacturers in the context of this EuP preparatory study.

Table 3-5 – Average load profiles of a mobile phone estimated by two EPS/BC manufacturers

Source	Time at load (h/d)					
	Unplugged	No load	25% rated load	50% rated load	75% rated load	100% rated load
M 1	-	23	-	-	-	1
M 2	12.75	10	0.25	-	-	1

Most evident difference in the stated load profiles is the ratio between no-load and unplugged. To assume that a remarkable number of consumers unplug the power supply from the mains regularly seems to be reasonable. Thus, the load profile given by M2 will be taken as use profile for the base case assessment.

Cordless (DECT) phones

Table 3-6 presents the average duty cycle for a cordless (DECT) phone estimated by manufacturer in the context of this EuP preparatory study. This load profile is in line with the references presented above (Table 3-2) and will be the basis to calculate the cordless phone segment of the base case.

Table 3-6 – Average load profile of a cordless phone estimated by a manufacturer

Source	Time at load (h/d)					
	Unplugged	No load	25% rated load	50% rated load	75% rated load	100% rated load
M 1	-	-	-	20	1	3

Digital camera

Some data is available on the frequency of use of digital cameras. However, how often a camera is used is not the same as the frequency of charging the battery (either with an EPS or a dedicated BC). With a fully charged battery, it is usually possible to photograph some days. For most consumers, the intensive use of camera is very punctual: special occasions and holidays. Majority of the time the camera is not used, and thus not regularly charged. It is feasible to assume 1-2 charging cycles per month. A corresponding EPS/BC load profile is shown in Table 3-7.

Table 3-7 – Estimated average load profile of a digital camera EPS/BC.

Time at load (h/d)					
Unplugged	**No load**	**25% rated load**	**50% rated load**	**75% rated load**	**100% rated load**
13.7	10	0.05	-	-	0.25

Personal care appliances

Table 3-8 presents the average duty cycle for a shaver estimated by an EPS/BC manufacturer in the context of this EuP preparatory study. Other personal care products such as epilators, hair clippers, etc., have load profiles different than this but they are likely to be unplugged for most of the time and hence not presented here.

Table 3-8 – Average load profile of a shaver estimated by an EPS/BC manufacturer

Source	Time at load (h/d)					
	Unplugged	**No load**	**25% rated load**	**50% rated load**	**75% rated load**	**100% rated load**
M 1	-	-	22	-	-	2

Set-top box / Modem / Wi-Fi access point

Set-top/triple-play boxes, modems and Wi-Fi access points are appliances that are typically on 24 hours per day (see Table 3-2). However, this does not imply that an EPS of such a product is at full load all of the time as the end-appliance is most of the time idle, albeit on. A prudent estimation is that the EPS is about 3 hours per day under full load (100% of the rated load) and the rest of the time, i.e. 21 hours per day under 50% load condition (of the rated load).

Universal Battery Chargers

According to a battery charger manufacturer, 50 charging cycles per year per BC is a reasonable assumption. Per charging cycle, approximately 9 hours is spent in charging mode and 3.5 hours in maintenance mode. On average, a charger is assumed to remain 2.75 hours per day in no-load mode.

3.1.3.2 Middle output power range (10-49 W)

Printers

Table 3-9 presents usage patterns for inkjet printers from two different sources. Laser printers are not relevant for this study as they usually do not have external power supplies.

Table 3-9 – Usage patterns for inkjet printers from literature

Type of use	Reference*	Time in an operating mode (hours/week)		
		Off°	Standby	On
Residential	1	163	0	5
	2	164.5	2.8	0.7
Commercial	1	97	60	11
	2	128	39	1

* 1: LBL (2001) Electricity Used by Office Equipment and Network Equipment in the U.S, Lawrence Berkeley Laboratories, 2001. In: NAEEEC (2003) Computer Printers – Standby Product Profile 2003/03. Australia.
2: Swiss Federal Office of Energy (1999) Bestimmung des Energieverbrauchs von Unterhaltungselektronikgeräten, Bürogeräten und Automaten in der Schweiz.

° The printer is off, but the EPS is still likely to be plugged in and connected to the printer.

Only the smaller desktop printers come with an external power supply. From the above table the households, i.e. residential sector, consequently is much more important for the EPS load profile than the commercial sector.

Table 3-10 presents the average duty cycle for a printer EPS estimated by two printer manufacturers in the context of this EuP preparatory study.

For private use and the SOHO sector (small office / home office) a daily printing time of 30 minutes, corresponding to approximately 100% load, as given by OEM2 seems not to be reasonable, whereas the given 1 minute per day by OEM1 seems to be quite low in comparison. For further calculations of the base case we assume a load profile with 100% for 6 minutes per day. As the 25% load rate is by far the dominating part of the use phase, the uncertainties regarding the 100% load status are irrelevant for the overall results.

Table 3-10 – Average load profile of a inkjet printer EPS estimated by two manufacturers

Source	Time at load (h/d)					
	Unplugged	No load	25% rated load	50% rated load	75% rated load	100% rated load
M 1	-	-	23.9833 (15% rated load)	-	-	0.0167
M 2	-	-	23.5	-	-	0.5
Assumption	-	-	23.9	-	-	0.1

POWER TOOLS

The frequency of use of different power tools and the resulting number of charging cycles are usually very different for professional and private uses:

- Power tools for professional use – A charger for power tools in professional use is typically used twice a day, five days per week for charging batteries (professional users typically have two batteries for their cordless power tool). The cordless power tools and their chargers are portable devices which are typically transported from site to site by their user (e.g. craftsman, construction worker, etc.). As such, the chargers tend not to be subject to continuous use, neither are they plugged into the mains supply continuously, even if they are frequently used. Even within professional users, some charge their batteries on the jobsite while others charge ahead of time in the workshop which results in very different use cycles. Namely, in the latter case longer time in maintenance mode can be expected. Approximately 500 charging cycles per year can be assumed for a professional power tool charger.
- Consumer tools (DIY – do-it-yourself) – DIY are not used very frequently. On average, a heavy user will use a power tool for 6 hours during the warranty period of 2 years, i.e. 3 hours per year. However, these three hours may be accumulated on multiple occasions, number of which varies from one user to another. So, the number of charging cycles is expected to be higher than three. It is reasonable to assume that there are approximately five charging cycles per year.[6] DIY battery chargers are usually unplugged when not in use.

The charging time per charging cycle depends mostly on the technical parameters of the charger. An average charging time of approximately 1 hour per charging cycle can be assumed for both professional and DIY tool chargers. In reality, some DIY chargers have significantly longer charging times (upto 6 hours), but often the battery of a DIY tool may not be completely empty at the start of charging, which can result in shorter charging time.

The time in the maintenance mode[7] depends on the end-user: an hour per cycle can be a reasonable assumption. Time in no-load[8] is expected to be limited as discussed above: on average 2 hours per day for a professional charger and 0.02 hours per day for DIY charger.

3.1.3.3 HIGH OUTPUT POWER RANGE (> 49 W)

HALOGEN LIGHTING

For halogen lighting transformers, a use time of 8 hours per day can be assumed. This may overestimate their use time in households on weekdays. But on the other hand, significant numbers of halogen lamps are used for display windows in shops with much longer use times. For the rest of the time the transformer is off.

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6 Lot 7 stakeholder comment.
7 A fully loaded battery remaining in the charger
8 Charger connected to the electric grid without battery

LAPTOPS

There is a substantial trend away from desktop computers towards laptops. Laptop replacing a desktop computer can have a user pattern very similar to the latter. Based on a German socio-scientific market analysis[9], a private computer is used every day in most of the cases. However, the duration of use varies widely from one day to another depending on the availability of personal time and need to carry out a particular task (e.g. surf the internet, work on digital photos). Of course, there is also inter-personal/-household variation (fan of computers or game player vs. a person who only checks few e-mails; computer used by one person vs. computer used by all the members of a big family).

While most rechargeable devices are designed for use when detached from the charger, laptops are frequently used while still attached to the power supply. Laptop as a substitute for a desktop computer enforces this behaviour and laptops are increasingly plugged into a mains supply for the majority of their run time.

Like most computers, laptops have an automatic low-power or ‘sleep’ mode. Therefore when a laptop is in use while attached to the charger it can be classified according to the operating mode of the laptop itself (off, sleep, active). Therefore, for each main mode (off, sleep / passive standby and active) there are two sub-modes: fully charged and charging. There is also an extra ‘off’ mode, when the laptop is detached from the power supply.[10] All these seven different operating modes demand a certain load from the EPS, i.e. potentially implying seven different efficiency levels.

Table 3-11 presents the average duty cycle for a laptop computer estimated by two laptop manufacturers in the context of this EuP preparatory study.

Table 3-11 – Average load profile of a laptop computer estimated by two manufacturers

Source	Time at load (h/d)					
	Unplugged	No load	25% rated load	50% rated load	75% rated load	100% rated load
M 1	-	15	-	5	-	4
M 2	-	12	2	3	4	3
Average	-	13.5	1	4	2	3.5

For the base case assessment an average of both load profiles will be taken as the stated profiles are in principle quite similar. However, this may somewhat overestimate the usage time for some private users.

9 ISOE GmbH (2006) “Eco Top Ten Computer” presentation

10 NAEEC (2004) Minimum Energy Performance Standards - External Power Supplies, report no. 2004/07

3.1.4 CONSUMER – PRODUCT DESIGN INTERACTION

There are some external power supplies/battery chargers on the market, which have a mains switch that allows the consumer to turn off the EPS/BC completely without removing it from the mains socket. However, with regard to user convenience, this option is useful only for desktop[11] EPSs/BCs (e.g. a laptop EPS). For wall plug models[12], there is no difference: the user has to reach to the mains socket whether it is to pull out the EPS/BC or to switch it off. It is assumed that only a minority of users would make use of switches even on desktop EPSs/BCs as the energy consumption of EPSs in no load is usually not considered significant, if known at all, by the consumer.

For battery charging operations, the user needs to know when the batteries are fully charged. This can be provided by an indicator light or state of charge meter, either as part of the charger or the end-device (e.g. displayed status of a mobile phone or indicator light of a laptop or shaver). Only such an indication allows the user to operate BCs adequately, namely to charge the batteries fully[13]. An indication of the fully charged state also enables the user to disconnect the charger, thus reducing the standby times, and to save batteries from overheating (which is an issue for some chargers) resulting in longer battery lives. However, to save batteries from overcharging technical measures are the much more reliable solution.

3.1.5 BEST PRACTICE IN SUSTAINABLE PRODUCT USE

As most EPS and BC do not have an off-switch, the Best Practice in product use in general is to unplug the product when the end-application does not require it, i.e.:

- unplug an EPS of a portable end-appliance as soon as the appliance battery is fully charged
- unplug a BC as soon as the battery(ies) are fully charged
- unplug an EPS of a non-portable end-appliance when the appliance is not in use, given that this does not hampering the main function of the end-appliance. For example, unplugging an EPS of a cordless phone when not speaking on the phone does not make sense, as an important function of a phone is to be able to receive calls.

These are gestures that are feasible to a certain extent. When unplugging a mobile phone from the EPS, the consumer should systematically unplug the charger at the same time. An EPS of a laptop can be unplugged for the night, and so on.

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11 An adaptor that has an additional AC line cord between the wall socket and the adapter. It typically sits on the “desk” or the floor. These adaptors are commonly associated with notebook PCs and are informally referred to as “lump-on-a-cord.”

12 An adaptor or charger that has no additional AC line cord and the adaptor plugs directly into the wall. These are most commonly associated with mobile phones and are informally referred to as a “wall wart.”

13 Charging batteries fully is usually recommended as each partial charging counts as a charging cycle. The number of charging cycles a battery can perform is limited and frequent partial charging can thus shorten battery lifetime.

On the other hand, an optimal behaviour vis-à-vis EPS and BC is hardly feasible for a consumer. To give few examples: Night time is for many consumers the most practical time to charge portable appliances, in this case the battery(ies) are often fully charged already in the middle of the night. Obviously, a consumer will not wake up only to unplug the EPS/BC. It is also not convenient to plug and unplug an EPS of a laptop computer several times during a full working day, for the purpose of optimal use. Similarly, it may be possible to unplug the EPS of an electric toothbrush for a couple of days once the battery is fully charged. However, it is very inconvenient if the battery runs out in the middle of evening routine, so a consumer prefers to leave the EPS connected all the time.

3.2. End-of-life behaviour

3.2.1 Product life time

In the United Kingdom, the E-SCOPE project (2000) generated some comprehensive data on the age of the current stock of household appliances through a quantitative survey of over 800 UK households and a series of focus groups.[14] Further, a report on an intrusive household survey in Australia (2005)[15] gives average age for some end-appliances which may be associated with EPS/BC. (Table 3-12)

Table 3-12 – Literature values regarding the lifetime and average age of appliances, which may be associated with EPS/BC.

Product category	Average age of discarded appliances (UK 2000)[14]	Average age of appliances in households (Australia 2005)[15]
Home and garden tools (power tools)	7	
Computers and peripherals	6	
Laptop computer		2.8
LCD monitor		1.4
Scanners		4.5
Inkjet printers		4.4
Computer speakers		4.1
Telephones, faxes and answering machines	6	
Radio and personal radio, stereo, CD	6	
Small work / personal care appliances	4	
Mobile phones and pagers	4	
Toys	4	

14 Edgar Hertwich (ed.) (2002) Life-cycle Approaches to Sustainable Consumption - Workshop Proceedings, 22 November 2002, Interim Report IR-02-073(pp 17-19). IIASA, Austria

15 E3 (2006) 2005 Intrusive Residential Standby Survey Report. Australia. Pages 89, 92. (available at http://www.energyrating.gov.au/library/index.html#STANDBY)

The lifetime of the appliances is of interest in this study as it is a parameter in the estimation of the EPS/ BC stock. In this context of products' environmental impacts, the focus is on the "active lifetime", i.e. the time in service. The literature values in Table 3-12 do not explicitly provide such data. They rather reflect the fact, that the overall lifetime (reflected by the age of discarded appliances) is often significantly longer than the active lifetime, as the "stocking in a drawer" phenomena is common in the case of small electric devices. They are frequently replaced by an up-dated product while still in a good working conditions. The old appliance is then stocked somewhere to be used in the case of a loss or technical problems of the new appliance, or with the intention of passing it on to somebody in need. The average age of appliances found in households does not necessarily reflect the average lifetime of these appliances either. For example, the LCD monitors in households are all relatively new, as the sales of these appliances have only recently reached significant levels.

The "active lifetime" of most of the power supply units is limited by the lifetime of the end product that it serves – due to compatibility and as each new end product comes with a new power supply unit. Obviously, this does not apply to universal battery chargers, but compatibility with future higher capacity cells/batteries can be an issue limiting the lifetime of a product.

Many end-appliances powered by EPS have fairly short active lifetimes, due to changing consumer trends and technological developments. It is reasonable to assume different active lifetimes for different end-application EPS and battery chargers. Appliances such as mobile phones and MP3 players are likely to be replaced more frequently than for example power tools. The active lifetime of some appliances, such as broadband modems is limited due to rapidly developing services and consequent appliance "up-dates". Table 3-13 presents the lifetimes assumed for major end-appliance EPS and battery chargers for the purpose of this study.

Table 3-13 – Assumed average lifetimes for EPS/BC by end-application

Product category	Average active lifetime (years)
Mobile phone EPS	3
Digital camera EPS/BC	3
Modem EPS	3
Personal hygiene appliance EPS/BC	4
Printer EPS	4
Laptop computer EPS	5
Battery chargers for AA/AAA batteries	5
Cordless phone EPS	6

Flat panel monitor EPS	6
Power tools BC	5.5[16]
Other EPS	5

3.2.2 PRODUCT DISPOSAL

One of the key findings of a recent UK survey[17], which assessed consumers' attitudes towards the disposal of small WEEE, was that there is a lack of recycling of small WEEE - 97% of items are not recycled and the majority are disposed of via civic amenity (CA) sites (33%) or in the household refuse (26%). Households that recycle regularly are more likely to dispose of small WEEE via a CA site in comparison to those who infrequently or never recycle. It appears that the act of recycling other household items (paper, glass, plastic, etc.) has a positive effect on the way small WEEE are disposed of. Consequently, the authors argue that the management of small WEEE must be integrated with other more widespread recycling services.

Term 'small WEEE' refers to appliances as big as a microwave oven. Hence, EPS and BC can be considered as 'very small WEEE'. The likelihood of these products to end up in the solid municipal waste fraction is high, should the separate collection require more than the very minimum effort.

3.2.3 BEST PRACTICE REGARDING THE END-OF-LIFE

According the Best Practice, at the end-of-life, EPS and BC should be taken to the WEEE collection point for recycling, if there are no opportunities for second-hand use together with the end-appliance.

3.3. LOCAL INFRA-STRUCTURE

The local infra-structure relevant to lot 7 is the availability of stable input voltage from the power grid. The switch-mode design is very sensitive to power grid "instabilities", however, linear transformer based power supplies are less susceptible to damage caused by variations in input voltage and therefore are preferred in countries with unstable mains power and where access for replacement is difficult. As the mains power in most of the Member States can be considered to be stable, this issue is of less concern in the EU context.

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16 Based on the life times of 7 and 2 years for DIY and professional power tools, respectively, which were averaged with the weights of 70% and 30%, respectively, according to the market shares.

17 Lauren Darby and Louise Obara (2005) Household recycling behaviour and attitudes towards the disposal of small electrical and electronic equipment. Resources, Conservation and Recycling, 44(1): 17-35.

3.4. POSSIBLE BARRIERS AND OPPORTUNITIES FOR ECO-DESIGN

3.4.1 LACK OF INFORMATION AND CONSUMER INTEREST

While the consumer pays for the energy consumption of a EuP, it is the OEM that selects the EPS/BC to accompany their cordless telephones, laptops, power tools, etc. This is a classic split incentive case where the purchaser of the EPS/BC is not the one that benefits directly from the reduced energy consumption.[18] Consequently, energy efficiency of EPS/BC is not the primary criteria affecting the choice of EPS/BC by an OEM, unless explicitly demanded by customers.

Currently, most consumers do not consider the annual energy consumption of home appliances in their purchasing decisions – perhaps with an exception of large household appliances for which EU energy label is obligatory. As an example, for computers, a German socio-scientific market analysis[19] concluded that people did not seem to have a clear idea of the real energy consumption of a computer, neither in its active use nor during stand-by. At the time of purchase there was an interest in ecological criteria, but due to the lack of labels/indicators, this did not really affect the buying decision. It may be also argued that an interest in ecological criteria does not mean that consumers will take these criteria into account in the actual purchase situation.

Consumers have even less consideration for the energy consumption or efficiency of an EPS or a BC, as they are not aware that efficiency is an issue in this context. Furthermore, many consumers are not aware that an EPS/BC plugged to the grid continues to consume some energy even if it is not connected to the end appliance or a battery. On the other hand, it may be argued that the energy consumption of EPS/BC at the product or even household level is too small to trigger consumer action.

Even for a conscious consumer, hardly any information is available specifically on the environmental performance of EPS/BC and most of the technical documentation deals with the main application. Currently the energy efficiency is not even marked on the common end-use appliances. Unlike household appliances, there is no energy guide label or equivalent to allow purchasers to compare the performance and operating costs of similar EPS/BC. But, a consumer label for EPS/BC is likely to be ineffective in any case, as the consumers buy the total product and not the EPS/BC.

Within the industry, standardised test procedure(s) for the measurement and reporting of EPS/BC energy efficiency are lacking, as identified in Task 1. However, the International Labelling Initiative has recently addressed the issue of efficiency marking[20] (see section 1.3.3.4) and the situation is rapidly changing. According to a stakeholder, by the beginning of 2007, almost all EPS

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18 Calwell, C. and Reeder, T. for Horowitz, N. (2002) Manufacturer Incentives for Energy Efficient External Power Supplies: A Feasibility Study. Natural Resources Defence Council, San Francisco, CA.

19 ISOE GmbH (2006) "Eco Top Ten Computer" Presentation

20 aimed at business-to-business and regulation enforcement rather than at consumers

of universal voltage input will be marked for efficiency so they can be sold in California. Further, voluntary labelling schemes have introduced some test procedures (see section 1.2.4).

3.4.2 COST FACTORS

In highly competitive electronics industry markets, very small price differences can have a substantial impact on the net profit. According to the current purchasing practises for EPS, very small cost differences (few cents of Euro) affect OEM's vendor selection. Consequently, the highly competitive EPS/BC industry places a premium on very low manufacturing cost, so even technologies that increase cost by cents can be rejected as too expensive. Even a constant cost solution may not be an option, as the target in many cases is to decrease costs. This cost sensitivity has inhibited the use of more efficient supplies in many applications.[21,22]

The incremental cost of more efficient power supply designs varies widely by size and type. With EPS that provide a power output of less than 10 watts, incremental costs may only be €0.30-1.00 – a small amount in an absolute sense, but a fairly high percentage premium on basic products with OEM prices of €1-3. In the wattage range of 15-60 watts, typical power supply prices can be €6-12, but additional costs for improved efficiency may also be higher.

Regarding individually sold EPS/BC, the cost differences between very efficient switch-mode power supplies and standard linear designs often become highly magnified as they move through the supply chain, making it appear at the retail level that the incremental cost difference is much greater than it really is. For example, a retailer may sell an efficient switching power supplies for a retail price of €29.95, while the manufacturing cost of this product may be in the range of 2 to 4 euros. The motivation of the retailer to sell this efficient product compared to an inefficient one will depend on the available profit margin. The margins available at different steps of the supply chain can indirectly influence the final sales choice of the product. Therefore, sales and costing factors can indirectly influence the choice and therefore sales of energy efficient EPS/BC.

3.4.3 COMPATIBILITY AND LIABILITY ISSUES

Majority of EPS/BC are sold bundled with an end-use appliance and these EPS/BC are usually designed and recommended to be used only with the appliance it is sold with, or with the specific batteries of the end-device. Sometimes, the manufacturers even use special connectors and inverse polarities to personalise EPS/BC for their specific appliances. This prevents EPSs/BCs from being reused by the consumer for other end-use appliances because of compatibility reasons. Furthermore, consumer rarely has a need to reuse an EPS/BC, as most of the end-appliances are automatically supplied

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21 Calwell, C. and Reeder, T. for Horowitz, N. (2002) Manufacturer Incentives for Energy Efficient External Power Supplies: A Feasibility Study. Natural Resources Defence Council, San Francisco, CA.

22 DOE (2004) Energy Consumption of Office and Telecommunications Equipment in Commercial Buildings, Vol.2: Energy Savings Potential. By Roth, K.W. et al. for Department of Energy, US.

with one. The lifetime of the EPS/BC therefore is usually restricted by the lifetime (technical lifetime or “fashion lifetime”) of the end-device.

Harmonisation of connectors as well as of output voltage and current would enable the consumer to extend the lifetime of the EPS. However, as the market trend is towards increasing efficiency of EPSs it might be preferable from an environmental point of view to get EPSs out of the market after a certain period and to replace these by more efficient ones, which might offset the additional impacts of increased production of EPSs (will be assessed in detail in task 6).

While reducing the number of appliances, universal EPS may compromise the energy efficiency, as the EPS will be designed for highest output and will be less efficient for lower outputs.

In addition, manufacturers have expressed the concern that the harmonisation of the connectors could lead to the (re-)use of EPS/BC with applications that are outside of the manufacturers testing and intended use. This could lead to unsafe power or thermal limit conditions, increasing manufacturers’ liability risks.

Due to liability issues, even EPSs bundled with end-appliances may be oversized to minimise liability, wasting additional energy when the products operate at part load.[23]

3.4.4 Opportunities for eco-design

Besides barriers to eco-design, there are factors that make “ecological“ design feasible especially for EPS and BC.

There are obvious benefits from the energy efficiency. A Californian study has indicated that the efficiency of most linear power supplies could be improved from 50-60% range to 80% or more, and switch-mode power supplies’ efficiencies could be increased from 70-80% range to roughly 90%. In most cases, the incremental cost for the improved efficiency is less than $1 and the resulting electricity savings for these products pay for their incremental cost very quickly – typically in 6 months to a year.[23]

Additionally, eco-design can bring about other benefits. The efficient EPS/BC tend to be smaller, lighter in weight, and more convenient to store and transport than their inefficient counterparts (see figure below). Consequently, they are generally favoured by consumers seeking portability, retailers attempting to minimize inventory costs, and manufacturers wanting to minimize shipping costs. In addition, efficient EPS/BCs operate at cooler temperatures, contain fewer parts, and are likely to result in greater product reliability.[23]

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[23] Calwell, C. and Reeder, T. for Horowitz, N. (2002) Power Supplies: A Hidden Opportunity for Energy Savings. Natural Resources Defence Council, San Francisco, CA

Figure 3-1 – Efficient EPS (left) versus less efficient EPS (right)

These "opportunities" have already resulted in a shift towards more efficient EPS in to some extent. This is visible in the EPS of many portable applications, such as mobile phones. Clients of ever smaller phones demand compact chargers, too.

3.5. CONCLUSIONS

Compatibility with an end-device limits the use of an EPS/BC with multiple appliances, which has lead to a plethora of them in every household. Energy and environmental performance of EPS/BC are largely unknown to consumers. There is a lack of information available on the energy consumption of these appliances, their contribution to the total energy consumption of a household, efficiency characteristics, etc. This lack of information results in no or low demand for an efficient EPS/BC from consumer's side. On the other hand, even if the information would be available, its effect on the consumer demand is expected to be small (see Section 3.4.1). A lack in consumer demand, along with a highly competitive business environment in this sector, discourages OEMs to favour efficient EPS/BC. Furthermore, the use of some eco-design features, such as mains switch, is very much dependent on the consumer behaviour.

Despite many potential barriers, there are also factors that make eco-design especially feasible for EPS and BC. Besides energy efficiency gains, their relatively small size, and lightness appeal to consumers, retailers and manufacturers.

Load profiles for different types of EPS/BC were established on the basis of typical end-use appliances. These values are used in the subsequent tasks to estimate the environmental impacts and Life Cycle Costs. Most of them are based on manufacturers' estimations, because usage patterns and load profiles specifically for EPS and BC have not been extensively studied and the manufacturers have the best available understanding on this issue. The load profile assumptions were verified against available published data on end-appliances, but the modes of these appliances do not necessarily reveal the time spent in different load conditions for an EPS or BC.

4. TECHNICAL ANALYSIS OF EXISTING PRODUCTS

Task 4 comprises of a technical analysis of existing products on the EU-market. Bill of materials and resources consumption during product life are some of the important parameters to be looked at. Such analysis provides general inputs for the definition of the base-cases in Task 5.

For some products, the BOM was obtained directly from EPS/BC manufacturers and/or OEM buyers. When such information was not readily available, the products were dismantled in the Fraunhofer IZM laboratory to establish the BOM. Due to confidentiality issues, such data for specific products cannot be published in public domain, so the BOMs presented below are normally an average of more than one EPS/BC models received from different manufacturers. For the same reason, the details of the product (manufacturer, brand, model number, etc.) are not mentioned.

Thirteen averaged "product cases" are presented. They are split in 3 main product categories based on the power output (low, middle and high power output power range), in line with the product categorisation that was presented and discussed in Task 1. For each main category, products that correspond to key applications are presented. In total, 21 external power supplies and battery chargers, covering the most important fields of application, served as basic products.

The production phase data, such as the "Bill of Materials" (BOM), is an important input in the calculation of the environmental impacts and costs for production, distribution, and end-of-life phases during the Task 5. As the assessment will be performed using EcoReport tool of the MEUUP methodology, the BOMs were collected and are presented in this section in EcoReport format. Due to specificities of EPS/BC, some clarifications and assumptions may be required which will be outlined appropriately.

4.1. PRODUCTION PHASE

4.1.1 COMPONENTS AND MATERIAL ASSUMPTIONS

- Cables

For the desktop type EPS, the mains cable is not included in the BOM as this is usually supplied as a separate, non-fixed part, whereas the cable on the application side, which is usually attached permanently to the power supply unit, is included. Furthermore, as no improvement potential for cables has been identified (besides the trivial recommendation to use shorter cables), this is not relevant for the study.

- Printed wired board (PWB) substrate

For EPS, usually the printed wired board substrates are based on CEM 1, CEM 3 or similar. Whereas CEM 3 is similar to FR4 (using a 'flies' type instead of woven glass fabric), CEM 1 is a paper based laminate with only one layer of woven glass fabric. The EcoReport methodology allows entries for three types of FR4 substrates and the 1/2 layer version is used for the EPS. However, it should be noted that CEM 1 is assumed to have a lower environmental impact than what is calculated using the FR4 data and hence this assumption may lead to a slight overestimation of environmental impacts.

- Primary scrap production

The default value of 25% proposed in the Ecoreport for primary scrap production during sheet metal production was assumed for all the products.

4.1.2 BILL OF MATERIALS

4.1.2.1 OUTPUT POWER < 10 WATTS

- **Mobile Phone EPS**

As outlined in the Market Analysis (Task 2), mobile phones represent the most important market segment in low power range i.e. below 10 W.

The product case on mobile phone external power supplies is based on three best selling switch-mode EPS from different manufacturers, as well as on one linear external power supply. Nowadays, because of the size constraints, most of the mobile phone EPS use switched-mode technology. However, to take into account the still existing market segment of linear external power supplies, such a device is taken into consideration as well. Data is averaged as follows: each of the three SMPS model contributed a share of 26.7%, which corresponds to a total of 80% for switched-mode technology in the mobile phone segment, and 20% for the linear power supply. The resulting average BOM for a mobile phone EPS is presented in Table 4-1.

Table 4-1 – Bill of Materials for an average mobile phone EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	**Case**	14,1	2-TecPlastics	**12-PC**
3	**Case**	9,6	1-BlkPlastics	**10-ABS**
4	**Metal pins etc.**	3,0	4-Non-ferro	**31-CuZn38 cast**
5	**Steel**	0,3	3-Ferro	**25-Stainless 18/8 coil**
6	Electronic assembly			
7	**PWB**	2,5	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
8	**Big caps & coils (THT)**			
9	Capacitors (electrolytic)	2,2	6-Electronics	**44-big caps & coils**
10				
11	Coils + transformers	24,8	6-Electronics	**44-big caps & coils**
12				
13				
14	**IC's**	0,1	6-Electronics	**47-IC's avg., 1% Si**
15	**SMD /LED's average**			
16	SMD Capacitors (ceramic, others)	0,1	6-Electronics	**48-SMD/ LED's avg.**
17	SMD Resistors, inductor filter	0,3	6-Electronics	**48-SMD/ LED's avg.**
18	**Solder**	0,6	4-Non-ferro	**52-Solder SnAg4Cu0.5**
19	**Miscellaneous**			
20	Diodes	1,3	6-Electronics	**47-IC's avg., 1% Si**
21	Transistors	0,4	6-Electronics	**47-IC's avg., 1% Si**
22	Resistors (THT)	0,3	6-Electronics	**48-SMD/ LED's avg.**
23	Ferrite core	0,4	3-Ferro	**24-Ferrite**
24				
25				
26	Cables			
27	**Copper wire**	7,5	4-Non-ferro	**29-Cu wire**
28	**Isolation, strain relief**	18,6	1-BlkPlastics	**8-PVC**
29	**Plug, slot**	1,6	7-Misc.	**45-slots / ext. ports**
30	**Nylon**	0,6	2-TecPlastics	**11-PA 6**
31				
32	Miscellaneous			
33	**Heatsink**	0,3	3-Ferro	**25-Stainless 18/8 coil**
34	div.	0,1		
35	Packaging			
36	**Cardboard**	11,9	7-Misc.	**56-Cardboard**

DECT Phone EPS

The product case on DECT phone[1] power supplies is based on a blend of two products types: an AC-AC power supply (where rectification to DC is taking place in the phone base station) and an AC-DC power supply employing linear technology. Both options are frequently used for external power supplies for DECT phones. However, it has to be noticed that the functionality of both

1 A cordless phone

options is not the same and such differences will be taken into account later. The average BOM for a DECT phone EPS is presented in Table 4-2.

Table 4-2 – Bill of Materials for an average DECT phone EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Upper and bottom case	18,0	2-TecPlastics	12-PC
3	Upper and bottom case - Polyphenyloxide	16,1	2-TecPlastics	
4	Plug	2,0	4-Non-ferro	31-CuZn38 cast
5	Plug: pin support, and label	1,1	1-BlkPlastics	8-PVC
6	Electronic assembly			
7	PWB	1,5	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
8	Big caps & coils (THT)			
9	Capacitors (electrolytic)	1,1	6-Electronics	44-big caps & coils
10	Coils + transformers	187,9	6-Electronics	44-big caps & coils
11	IC's			
12	DC/DC regulator	0,3	6-Electronics	47-IC's avg., 1% Si
13	SMD /LED's average			
14	SMD Capacitors (electrolytic)	0,5	6-Electronics	48-SMD/ LED's avg.
15	SMD Capacitors (ceramic, others)	0,1	6-Electronics	48-SMD/ LED's avg.
16	SMD Resistors, filters	1,5	6-Electronics	48-SMD/ LED's avg.
17	Diodes	0,5	6-Electronics	47-IC's avg., 1% Si
18	Miscellaneous			
19	internal wire	0,3	4-Non-ferro	29-Cu wire
20	Contacts	0,4	4-Non-ferro	31-CuZn38 cast
21	Solder	1,2	6-Electronics	52-Solder SnAg4Cu0.5
22	Cables			
23	Copper wire	13,8	4-Non-ferro	29-Cu wire
24	PVC (cable and connector)	11,9	1-BlkPlastics	8-PVC
25	Plug	3,1	6-Electronics	45-slots / ext. ports
26	Packaging			
27	Cardboard	17,7	7-Misc.	56-Cardboard
28	Master carton	20,0	7-Misc.	57-Office paper
29	Plastic bag	1,0	1-BlkPlastics	1-LDPE

Digital Camera EPS

Data for digital camera EPS is based on one best selling product in switched-mode technology from a leading OEM. Hence, unlike the BOMs presented earlier, the BOM of digital camera EPS (Table 4-3) is given on the “material or process” level of the EuP EcoReport only and not split up in more detail in further component categories. This kind of aggregation is required for confidentiality reasons.

Table 4-3 – Bill of Materials for digital camera EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Case	18,8	2-TecPlastics	12-PC
3	Electronic assembly			
4	PWB	4,1	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
5	Big caps & coils (THT)	20,2	6-Electronics	44-big caps & coils
6	IC's	2,0	6-Electronics	47-IC's avg., 1% Si
7	SMD /LED's average	0,2	6-Electronics	48-SMD/ LED's avg.
8	Solder	0,5	6-Electronics	52-Solder SnAg4Cu0.5
9	Cables			
10	Copper wire	26,1	4-Non-ferro	29-Cu wire
11	PVC free cable	26,1	1-BlkPlastics	3-LLDPE
12	Plug	2,5	6-Electronics	45-slots / ext. ports

Set-top box / Modem EPS

The product case on set-top box / modem EPS is based on one best selling product, representing a sales volume of 1 million units annually, using linear transformer technology. As this product case is also derived from one exemplary product, the BOM (Table 4-4) is given only on the “material or process” level of the EuP EcoReport and not split up in more detail.

Table 4-4 – Bill of Materials for set-top box / modem EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Case	25,3	2-TecPlastics	12-PC
3	Case	5,2	4-Non-ferro	31-CuZn38 cast
4	Case	0,3	3-Ferro	25-Stainless 18/8 coil
5	Electronic assembly			
6	PWB	2,8	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
7	Big caps & coils (THT)	12,2	6-Electronics	44-big caps & coils
8	IC's	4,1	6-Electronics	47-IC's avg., 1% Si
9	SMD /LED's average	0,2	6-Electronics	48-SMD/ LED's avg.
10	Solder	1,0	4-Non-ferro	52-Solder SnAg4Cu0.5
11	Cables			
12	Copper wire	13,2	4-Non-ferro	29-Cu wire
13	PVC	23,2	1-BlkPlastics	8-PVC
14	Plug	0,6	7-Misc.	45-slots / ext. ports
15	Nylon	0,6	2-TecPlastics	11-PA 6
16	Miscellaneous			
17	Heatsink	1,3	3-Ferro	25-Stainless 18/8 coil
18	Packaging			
19	Cardboard	10,0	7-Misc.	56-Cardboard

Personal Care Products' EPS

Table 4-5 presents the BOM for a personal care product EPS, namely a best selling model[2] for a shaver with sales figures in the EU of actually approximately 5 million units per year.

As this product case is derived from one exemplary product, the BOM is given on the "material or process" level of the EuP EcoReport only and not split up in more detail.

Table 4-5 – Bill of Materials for the product case of personal care product EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Case	25,3	2-TecPlastics	12-PC
3	Case	5,2	4-Non-ferro	31-CuZn38 cast
4	Case	0,3	3-Ferro	25-Stainless 18/8 coil
5	Electronic assembly			
6	PWB	2,8	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
7	Big caps & coils (THT)	12,2	6-Electronics	44-big caps & coils
8	IC's	4,1	6-Electronics	47-IC's avg., 1% Si
9	SMD /LED's average	0,2	6-Electronics	48-SMD/ LED's avg.
10	Solder	1,0	4-Non-ferro	52-Solder SnAg4Cu0.5
11	Cables			
12	Copper wire	13,2	4-Non-ferro	29-Cu wire
13	PVC	23,2	1-BlkPlastics	8-PVC
14	Plug	0,6	7-Misc.	45-slots / ext. ports
15	Nylon	0,6	2-TecPlastics	11-PA 6
16	Miscellaneous			
17	Heatsink	1,3	3-Ferro	25-Stainless 18/8 coil
18	Packaging			
19	Cardboard	10,0	7-Misc.	56-Cardboard

Standard Battery Charger for AA/AAA Batteries

Two best selling standard battery chargers were analysed for this product case: one for two and one for four AA / AAA batteries (both for NiMH and NiCd). Both are overnight chargers and as is common to these kinds of chargers, they use linear power transformation technology. The product specific data is averaged and the resulting average BOM data is presented in Table 4-6.

2 Though this product uses switched-mode technology, a remarkable share of EPS using linear technology still exists on the market for personal care products.

Table 4-6 – Bill of Materials for standard battery charger product case

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	**Upper Case**	29,000	2-TecPlastics	**12-PC**
3	**Lower case**	29,000	2-TecPlastics	**12-PC**
4	metal mountings	1,238	4-Non-ferro	**29-Cu wire**
5	Electronic assembly			
6	**PWB (single sided)**	7,150	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
7	**Big caps & coils (THT)**			
8	Capacitors (electrolytic)	0,200	6-Electronics	**44-big caps & coils**
9	Capacitor (film)	0,225	6-Electronics	**44-big caps & coils**
10	Coils + transformers	123,000	6-Electronics	**44-big caps & coils**
11				
12	**Slots / Ext. ports**			
13	Slot 230V	5,700	6-Electronics	**45-slots / ext. ports**
14	**IC's**			
15	IC (THT)	0,500	6-Electronics	**47-IC's avg., 1% Si**
16				
17				
18	**SMD /LED's average**			
19	SMD Capacitors	0,025	6-Electronics	**48-SMD/ LED's avg.**
20	SMD resistors	0,025	6-Electronics	**48-SMD/ LED's avg.**
21	SMD diodes	0,150	6-Electronics	**47-IC's avg., 1% Si**
22	SMD transistors	0,175	6-Electronics	**47-IC's avg., 1% Si**
23	**Miscellaneous**			
24	THT resistors (1)	0,200	6-Electronics	**48-SMD/ LED's avg.**
25				
26	THT Diodes	0,500	6-Electronics	**47-IC's avg., 1% Si**
27	THT Fuse	0,400	6-Electronics	**44-big caps & coils**
28	THT LED	2,000	6-Electronics	**47-IC's avg., 1% Si**
29				
30	switch AA/AAA	0,700	6-Electronics	**45-slots / ext. ports**
31	**Solder**	3,000	6-Electronics	**52-Solder SnAg4Cu0.5**
32				
33	Cables			
34	**Copper wire**	22,750	4-Non-ferro	**29-Cu wire**
43	Miscellaneous			
44	**Adhesive (plastic tape, yellow glue)**	0,300	1-BlkPlastics	
45	**Spacer (plastic cover)**	2,500	1-BlkPlastics	
46	**Screws**	0,500	3-Ferro	**21-St sheet galv.**
47	El Metal	88,100	3-Ferro	**25-Stainless 18/8 coil**
48	Eyelet and ring	0,025	4-Non-ferro	**31-CuZn38 cast**
49	Fibre paper	0,050	7-Misc.	**57-Office paper**
50	**Intern Wire**	4,900	4-Non-ferro	**29-Cu wire**

4.1.2.2 OUTPUT POWER 10 – 49 WATTS

Power tool charger

The product case on chargers for power tools is based on three products. These exemplary chargers, which represent the usual output power range of power tools had following output power ratings:

- 18 W (linear)
- 37.8 W (switched-mode)
- 51 W (switched-mode)[3].

This product segment covers a broad power spectrum and further, the use patterns vary extremely between professional tools, which are used daily, and do-it-yourself (DIY) tools, which are used infrequently. These three chargers are averaged arithmetically as they represent the usual power range of power tools adequately. The average power tool BOM is presented in Table 4-7.

[3] This charger does not fall in the power range of 10-49 W but is considered here to allow for a base case, which can cover power tools EPS in general.

Table 4-7 – Bill of Materials for power tool charger product case

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	**Upper Case + Lower Case**	171,700	1-BlkPlastics	**10-ABS**
3	**Light pipe**	0,267	2-TecPlastics	**12-PC**
4				
5	Electronic assembly			
6	**PWB (single sided)**	22,900	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
7	**Big caps & coils (THT)**			
8	Capacitors (electrolytic)	8,700	6-Electronics	**44-big caps & coils**
9	Capacitor (film) +ceramic	3,633	6-Electronics	**44-big caps & coils**
10	Coils + transformers	245,433	6-Electronics	**44-big caps & coils**
11				
12	**Slots / Ext. ports**			
13	Connectors	2,333	6-Electronics	**45-slots / ext. ports**
14	**IC's**			
15	IC (THT)+SMD	3,467	6-Electronics	**47-IC's avg., 1% Si**
16				
17				
18	**SMD /LED's average**			
19	SMD Capacitors	0,033	6-Electronics	**48-SMD/ LED's avg.**
20	SMD resistors	0,100	6-Electronics	**48-SMD/ LED's avg.**
21	diodes, transistors, thyristors	7,800	6-Electronics	**47-IC's avg., 1% Si**
22				
23	**Miscellaneous**			
24	THT resistors	12,767	6-Electronics	**48-SMD/ LED's avg.**
25	heat sink	16,367	4-Non-ferro	**27-Al diecast**
26	spacer	0,333	1-BlkPlastics	**10-ABS**
27	Relais	3,333	6-Electronics	**45-slots / ext. ports**
28	NTC	0,333	6-Electronics	**48-SMD/ LED's avg.**
29	Nickel plated terminals	0,733	4-Non-ferro	**31-CuZn38 cast**
30	THT fuse	0,500	6-Electronics	**44-big caps & coils**
31	**Solder**	6,233	6-Electronics	**52-Solder SnAg4Cu0.5**
32				
33	Cables			
34	**Copper wire**	33,433	4-Non-ferro	**29-Cu wire**
35	**PVC**	26,967	1-BlkPlastics	**8-PVC**
36	**Plug**	27,933	6-Electronics	**45-slots / ext. ports**
43	Miscellaneous			
44	**adhesive**	3,100		
45	**screws**	2,500	3-Ferro	**21-St sheet galv.**

Printer EPS

Two inkjet printer EPS were analysed. Both of them, as common for this product segment, employ switched-mode technology. BOM data for a printer EPS product case, presented in Table 4-8, is based on the arithmetic average of the two products.

Table 4-8 – Bill of Materials for printer EPS product case

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	**Upper and lower Case**	51,345	2-TecPlastics	**12-PC**
3	**Screws**	0,400	4-Non-ferro	**26-Al sheet/extrusion**
4	**Screws**	0,491	3-Ferro	**21-St sheet galv.**
5	Electronic assembly			
6	**PWB (single sided)**	13,815	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
7	**Big caps & coils (THT)**			
8	Capacitors (electrolytic)	11,943	6-Electronics	**44-big caps & coils**
9	Capacitor (film)	2,250	6-Electronics	**44-big caps & coils**
10	Coils + transformers	33,335	6-Electronics	**44-big caps & coils**
11	other big caps and coils	1,000	6-Electronics	**44-big caps & coils**
12				
13	Capacitor (ceramic)	2,015	6-Electronics	**44-big caps & coils**
14	**Slots / Ext. ports**			
15	slot 230V	8,490	6-Electronics	**45-slots / ext. ports**
16	**IC's**			
17			6-Electronics	**47-IC's avg., 1% Si**
18	ICs	1,410	6-Electronics	**47-IC's avg., 1% Si**
19	**SMD / THT**			
20	SMD Capacitors	0,113	6-Electronics	**48-SMD/ LED's avg.**
21	SMD resistors	0,127	6-Electronics	**48-SMD/ LED's avg.**
22	diodes	2,536	6-Electronics	**47-IC's avg., 1% Si**
23	transistors	1,133	6-Electronics	**47-IC's avg., 1% Si**
24	SMD miscelleneous	0,850	6-Electronics	**48-SMD/ LED's avg.**
25	**Miscellaneous**			
26	THT resistors	1,135	6-Electronics	**48-SMD/ LED's avg.**
27				
28				
29	THT Fuse	1,095	6-Electronics	**44-big caps & coils**
30	THT ferrit	0,170	3-Ferro	**24-Ferrite**
31	THT bridge, jumper	0,125	4-Non-ferro	**28-Cu winding wire**
32	THT plug	2,165	1-BlkPlastics	**8-PVC**
33	Aluminum Heat sink	3,605	4-Non-ferro	**26-Al sheet/extrusion**
34				
35	**Solder**	1,593	6-Electronics	**52-Solder SnAg4Cu0.5**
36	Cables			
37	**Copper wire**	14,800	4-Non-ferro	**29-Cu wire**
38	**PVC**	14,800	1-BlkPlastics	**8-PVC**
39	**Plug**	4,330	6-Electronics	**45-slots / ext. ports**
Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
42	Miscellaneous			
43	**adhesive**	0,150		
44	**rubber, gum**	0,100		
45	**stealslide**	0,585	3-Ferro	**21-St sheet galv.**
46	**fusecover**	0,130	1-BlkPlastics	**8-PVC**
47	**sheat assembly**	**0,25**	4-Non-ferro	**26-Al sheet/extrusion**
48	**glue**	0,900	2-TecPlastics	**12-PC**
49				
50				
51	Packaging			
52	**foil**	2,105	1-BlkPlastics	**1-LDPE**

4.1.2.3 Output power > 49 Watts

Transformer for halogen lighting

Transformers for halogen lighting span a broad range of output power, but 60 W model dominates the market, followed by 35 W and 105 W. Data on two 60 W transformers, which can be considered as representative for the product segment, was analysed: one using magnetic transformer (with an EI-core) and another with an electronic transformer. Bill of Materials data entries for the magnetic and electronic transformer are presented in Table 4-9 and Table 4-10, respectively.

Most of the weight of the magnetic transformer is coil and core[4], but also the typical epoxy filler, which seals the whole assembly hermetically makes up a larger part of the overall transformer weight of 1250 g.

Table 4-9 – Bill of Materials for halogen lighting transformer (magnetic)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Case	60,0	1-BlkPlastics	10-ABS
3	Electronic assembly			
4	PWB	25,0	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
5	Transformer	960,0	6-Electronics	44-big caps & coils
6	Terminal block	5,0	6-Electronics	45-slots / ext. ports
7	Miscellaneous			
8	Filler	200,0	2-TecPlastics	14-Epoxy
9	Packaging			
10	Cardboard	15,0	7-Misc.	56-Cardboard

The printed circuit board used for the electronic transformer actually is a phenolic based FR1 substrate.

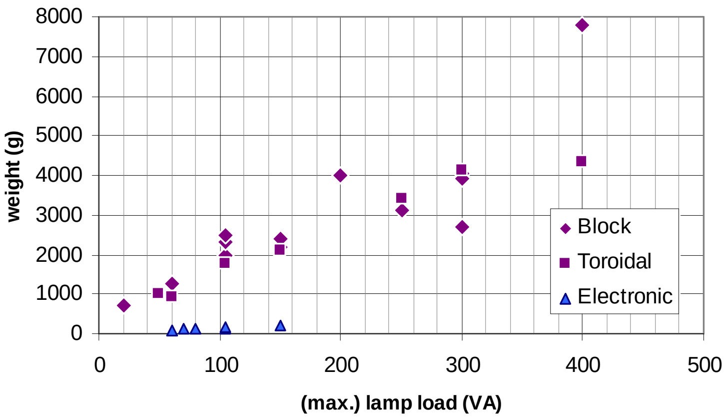
4 Categorising the transformer itself as “big caps & coils” is in line with the EcoReport methodology as such, but it has to be kept in mind that this entry is derived to a large extend from electrolytic capacitors (with a high content of e.g. aluminium), which have a totally different composition than the transformer.

Table 4-10 – Bill of Materials for halogen lighting transformer (electronic)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Upper case	65,6	4-Non-ferro	26-Al sheet/extrusion
3	Bottom case	17,9	1-BlkPlastics	10-ABS
4	Electronic assembly			
5	PWB	17,2	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
6	Big caps & coils (THT)	99,7	6-Electronics	44-big caps & coils
7	Diodes, transistors, varistors	6,9	6-Electronics	47-IC's avg., 1% Si
8	ICs	0,0	6-Electronics	47-IC's avg., 1% Si
9	SMD /LED's (others)	0,0	6-Electronics	48-SMD/ LED's avg.
10	Terminal block	3,3	6-Electronics	45-slots / ext. ports
11	Miscellaneous			
12	Polyester film	4,1	1-BlkPlastics	1-LDPE
13	Packaging			
14	Back paper packaging	5,0	7-Misc.	56-Cardboard
15	Plastic slide pack	8,0	1-BlkPlastics	8-PVC

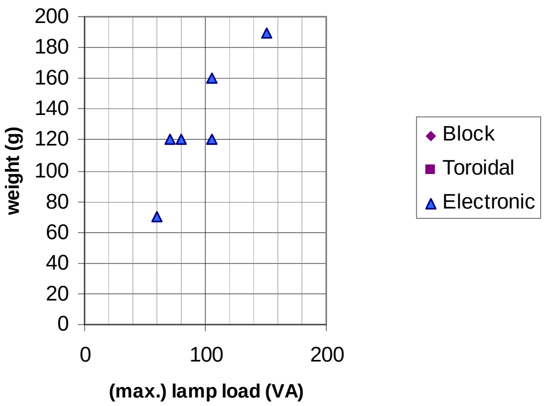
To give an indication how the BOM changes in terms of weight (not actually in components), the graphs below show the weights for a couple of magnetic (block / EI-core and toroidal core) and electronic halogen lighting transformers[5].

Figure 4-1 – Weight of halogen lighting transformers in correlation to maximum lamp load



5 Magnetic transformers are usually designed for a specific lamp load, whereas electronic ballasts are designed to cover a broader range of lamp wattages. The upper limit of the given range (max. load) is referenced in the graph.

Figure 4-2 – Enlarged section of the Figure 4-1 (above), illustrating the dependencies for the electronic transformers specifically



From these statistics, a correlation of weight and (max.) lamp load can be extrapolated as follows:

$$m_{transformer} = Factor(g/VA) \cdot P(VA)$$

where $m_{transformer}$ = weight of the transformer in grams
P = maximum lamp load in VA

This factor is roughly 15 g/VA[6] for magnetic transformers and 1.25 g/VA[7] for electronic transformers. As an approximation, this factor can be assumed for each individual entry of the BOM as well, however, for example the terminal blocks will remain the same.

Actually, no significant difference of EI-core and toroidal core transformers can be observed in terms of weight-power correlation.

Laptop EPS

The market segment of EPS with maximum rated output power above 49 W is dominated by the EPS for laptop computers (see Task 2, market analysis). Two leading laptop OEMs provided data on 65 W EPS which is quite common in the laptop market. In addition, data on one 90 W EPS was also provided. The latter will enable to crosscheck the influence of the power factor correction which is required, in general, for EPS larger than 75 W input, and affects electronics layout as well as efficiency and no-load losses (see separate analysis below).

Table 4-11 and Table 4-12 show the Bill of Materials for the averaged values of the 65 W laptop EPS and for the 90 W EPS, respectively. Due to the power factor correction stage and the higher power range, the BOM for the 90 W EPS, in comparison with the 65W laptop EPS, contains significantly heavier coils and

6 Meets the survey data fairly well in the range from 20 to 300 VA
7 For the range 60 to 150 VA

transformers and also much higher values for IC weight. However, the latter results mainly from THT diodes and transistors.

Table 4-11 – Bill of Materials for an average EPS for laptops of 65 W

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Upper Case + Lower Case	47,885	2-TecPlastics	12-PC
3				
4				
5	Electronic assembly			
6	PWB (single sided)	7,212	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
7	Big caps & coils (THT)			
8	Capacitors (electrolytic)	18,076	6-Electronics	44-big caps & coils
9	Capacitor (film) +ceramic	3,935	6-Electronics	44-big caps & coils
10	Coils + transformers	44,040	6-Electronics	44-big caps & coils
11				
12	Slots / Ext. ports			
13	Slot 230V	5,245	6-Electronics	45-slots / ext. ports
14	IC's			
15	IC (THT)+SMD	0,505	6-Electronics	47-IC's avg., 1% Si
16				
17				
18	SMD /LED's average			
19	SMD Capacitors	0,105	6-Electronics	48-SMD/ LED's avg.
20	SMD resistors +trasnistor	0,268	6-Electronics	48-SMD/ LED's avg.
21	SMD diodes	0,093	6-Electronics	48-SMD/ LED's avg.
22				
23	Miscellaneous			
24	THT resistors + transitors + Diodes +rectifier	5,945	6-Electronics	48-SMD/ LED's avg.
25				
26				
27	THT Fuse	0,290	6-Electronics	48-SMD/ LED's avg.
28	THT ferrit	0,265	6-Electronics	48-SMD/ LED's avg.
29	THT bridge, jumper	0,090	4-Non-ferro	29-Cu wire
30				
31	Solder	0,837	6-Electronics	52-Solder SnAg4Cu0.5
32				
33	Cables			
34	Copper wire	34,125	4-Non-ferro	29-Cu wire
35	PVC	34,125	1-BlkPlastics	8-PVC
36	Plug THT	3,215	6-Electronics	45-slots / ext. ports
37	Plug low voltage	6,190	6-Electronics	45-slots / ext. ports
43	Miscellaneous			
44	Adhesive (Silicone)+Spacer (elastomer...)+tape	7,335		
45				
46	Screws + metal mountings	1,515	3-Ferro	21-St sheet galv.
47	Aluminum Heat sink	22,735	4-Non-ferro	26-Al sheet/extrusion
48	heat sink with cooper	22,800	4-Non-ferro	30-Cu tube/sheet
49	Shield (plastic)	2	1-BlkPlastics	4-PP
50	Intern Wire	0,405	4-Non-ferro	29-Cu wire
51	Intern Wire	0,810	1-BlkPlastics	8-PVC

Table 4-12 – Bill of Materials for a typical laptop EPS of 90 W

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	case	73,000	2-TecPlastics	12-PC
3	metal mountings	3,070	3-Ferro	25-Stainless 18/8 coil
4	Electronic assembly			
5	PWB	13,200	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
6	Big caps & coils (THT)	144,396	6-Electronics	44-big caps & coils
7	Slots / Ext. ports	4,700	6-Electronics	45-slots / ext. ports
8	IC's	3,068	6-Electronics	47-IC's avg., 1% Si
9	SMD /LED's average	1,428	6-Electronics	48-SMD/ LED's avg.
10	Miscellaneous			
11	THT Fuse	0,300		
12	heat sink for coils	1,900	4-Non-ferro	30-Cu tube/sheet
13	Solder	1,221	6-Electronics	52-Solder SnAg4Cu0.5
14	Cables			
15	Copper wire	44,000	4-Non-ferro	29-Cu wire
16	PVC	44,000	1-BlkPlastics	8-PVC
17	Plug	7,900	6-Electronics	45-slots / ext. ports
18	Miscellaneous			
19	heat sink	29,600	4-Non-ferro	30-Cu tube/sheet
20	spacer	6,600	1-BlkPlastics	
21	heat sink 2	17,400	4-Non-ferro	26-Al sheet/extrusion
22	div. plastic sheets	0,520		
23	lacing cord	10,300		

4.2. DISTRIBUTION PHASE

4.2.1 ASSUMPTIONS REGARDING THE PACKAGED PRODUCTS

As the external power supply or charger usually comes in a package with the end-device – an exception are EPS which are sold as replacement parts and chargers for standard AA/AAA batteries – in principle an allocation of the full product's package size would be needed. Basic assumption is: the EPS or charger does not have an influence on the product package as it is either negligible compared to the overall product size (e.g. for laptops, monitors) or for marketing reasons a certain "over-sized" package for the product as a whole is common (e.g. for mobile phones, digital cameras). As allocation rule, the entry for "volume of packaged final product" is calculated as a cuboid containing the EPS / charger. Table 4-13 presents the assessed packaging volumes for the different product cases.

Table 4-13 – Volume of packed final product for products cases

Output power range	Product case	Packaging volume (m^3)
< 10 W	Mobile phone EPS	0.00025
	DECT phone EPS	0.0003
	Digital camera EPS	0.0003
	Set-top box / Modem EPS	0.0003
	Personal care product EPS	0.0003
	Standard BC	0.0005
10 – 49 W	Power tool BC	0.0005
	Printer EPS	0.0003
> 49 W	Halogen lighting transformer (electronic)	0.0004
	Halogen lighting transformer (magnetic)	0.0006
	Laptop EPS (65 W)	0.0005
	Laptop EPS (90 W)	0.0005

The following Table 4-14 presents a pre-assessment sensitivity analysis for this packaging aspect. Even if the allocated package volume was three or five times of the cuboid, the primary energy consumption impact increases only slightly. The main reason is that the EcoReport tool foresees a remarkable fixed overhead of environmental impact for offices, etc., which cannot be influenced by the package size. On the other hand, as this overhead cannot be influenced by the size and the design, this entry is irrelevant for the discussion on improvement options.

Table 4-14 – Sensitivity of the "Packaged Volume" entry

"packaged volume" in m³	correlation with a laptop EPS[8]	Energy GER in MJ (distribution phase)
0.0003497	= volume of a cuboid containing the EPS / charger	**52.73**
0.0010491	= **3 x** volume of a cuboid containing the EPS / charger	**55.19**
0.0017485	= **5 x** volume of a cuboid containing the EPS / charger	**57.66**

Regarding the weight of packaged products, for external power supplies it ranges from slightly above 100 g for mobile phone EPS to approx. 400 g for

8 As EPSs for laptops are among the largest ones covered by the scope of this study, this aspect is even less critical for smaller power supplies e.g. mobile phone chargers.

laptop EPS. Standard battery chargers as packaged products are in the range of few hundred grams each. Halogen lighting transformers only come with a lightweight cardboard package. Hence, the weight of the packaged transformer comes close to the initial weight of the transformer itself. Especially for magnetic transformers the weight of the product itself is by far the dominating part of the overall packaged product weight.

4.3. USE PHASE (PRODUCT)

According to the MEEUP methodology, for the use phase the annual resources consumption and direct emissions during product life should be assessed according to the test standard conditions (ideally defined in subtask 1.2), as well as in off-standard conditions, i.e. at variable load. However, the task 1.2 of this study concluded that no official test standards exist for the EPS / BC, which takes into account the use profile. The ENERGY STAR for Battery Charging Systems defines a test cycle, but not a standardised use profile compatible with EcoReport. Therefore, it is feasible to assess the impacts in off-standard conditions only.

The electricity consumption is the only resource consumption during the use of EPS / BC with the exception of standard battery chargers (see the appropriate paragraph in section 4.3.1.6). There are no direct emissions during product use.

4.3.1 ENERGY EFFICIENCY AND NO-LOAD CONSUMPTION ASSUMPTIONS

Energy efficiency and no-load consumption are one of the key parameters for assessing the energy use of any energy using product. Such data on individual products was supplied by the industry as an input to this study. However, it is not expected that these product cases can lead to "average" efficiency and no load losses data (for statistical reasons a number of approximately 20 product cases is by far too low to arrive at a representative efficiency data). Nevertheless, measurements of a representative number of EPS are out of scope and feasibility of this study. Therefore, in addition to the product data, the efficiency / no load data from other sources was taken into account, namely:

- Data from statistics / measurement campaigns / compliance schemes
- Market knowledge from experts

Some pre-calculations and settings were also needed, in order to derive suitable electricity use entries for the EcoReport.

4.3.1.1 GENERAL ASSUMPTIONS REGARDING ELECTRICITY USE

- **External power supplies**

When assessing the **electricity consumption** of an EPS, the energy provided to the end-appliance should not be taken into account, as this energy only passes through the EPS and will be consumed by the end-appliance. The relevant energy consumption of an EPS comprises the losses during power transformation (due to inefficiency) as well as the no-load losses. Thus, the shown EcoReport entries regarding electricity consumption do not represent the energy input to the power supply unit, but only the losses, which occur in the power supply:

$$P_{\text{"consumption"}} = \Delta P = P_{in} - P_{out} = (1-\eta) \cdot P_{in} = (\frac{1}{\eta} - 1) \cdot P_{Out}$$

Efficiency η is defined as the ratio of output power and input power:

$$\eta = \frac{P_{out}}{P_{in}}$$

Although the efficiency varies with the load – and thus with P_{out} – the general base cases will be calculated with the average efficiency value for all loads. But in the detailed analysis also the efficiency differences will be investigated.

On-mode of an external power supply represents not a fixed status with fixed consumption, but has to be seen rather as a load profile. The on-mode consumption is calculated by considering the (efficiency) losses in the four load points 25, 50, 75 and 100% load, matched with the use profile (time dedicated to the different loads):

$$E_{on-mode} = (\frac{1}{\eta} - 1) \cdot (t_{25\%} \cdot P_{out25\%} + t_{50\%} \cdot P_{out50\%} + t_{75\%} \cdot P_{out75\%} + t_{100\%} \cdot P_{out100\%})$$

Notice: With this definition, the on-mode also covers working conditions, where the end-application might be in standby. For several end-applications, 25% of load represents the standby status, e.g. for inkjet printers. From the viewpoint of the power supply unit, this is only another working mode where the EPS fulfils its main function, namely providing power as required by the end-device – in whatever status the end-device might be.

This approach corresponds with the active mode definition of the ENERGY STAR criteria: *"The condition in which the input of a power supply is connected to line voltage ac and the output is connected to a dc or an ac load drawing a fraction of the power supply's nameplate power output greater than zero.*"

Consequently, there is no **standby-mode** calculated for external power supplies. Entries in the EcoReport template are zero.

The **off-mode** entries correspond to the no-load status of the EPS, which is defined by ENERGY STAR as follows: *"The condition in which the input of a power supply is connected to an ac source consistent with the power supply's nameplate ac voltage, but the output is not connected to a product or any other load."*

Table 4-15 – Use phase entries in the EcoReport Tool

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	1	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0	kWh	0
213	On-mode: No. Of hours, cycles, settings, etc. / year	0	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,00	MWh (=000 kWh)	65

As the EcoReport tool does not foresee entries for the different load modes (see table above), following pre-calculations and settings apply for the presentation of entries for the individual base cases:

- Pos. no. 212: Energy losses of EPS throughout the different load conditions for one day
- Pos. no. 213: Consequently the unit for "no. of hours, cycles, settings, etc. / year" is "days/year" (=365)
- Pos. no. 214 and 215: Zero for EPS (see above)
- Pos. no. 216: Consumption in no-load
- Pos. no. 217: Unit is "hours / year" (notice: unit is different than that for the on-mode entries)

Battery chargers

For battery chargers, specifically number and duration of charging cycles are taken into account, but correlated to load profiles as outlined for EPS above.

4.3.1.2 Data from statistics / measurement campaigns / compliance schemes for External Power Supplies (excluding halogen lighting transformers)

There are four major sources on EPS performance: a broad 2003 measurement campaign in USA, Australia and China, EPS data in the framework of the EU Code of Conduct, measurements by the UK Market Transformation Programme and the database on products compliant with the ENERGY STAR specification. As the market for external power supplies is a global one, global data can serve as a basis for orientation, but with the following constraints:

- Market share of end-applications varies among the different countries, affecting also the EPS market
- Single input voltage EPS for the US market (110 V) are irrelevant for the EU market.

Measurement Campaign USA, Australia, China 2003

The two figures below show the results of a broad campaign of efficiency measurements[9], performed in Australia, China and the US in 2003 in correlation with a proposed specification for China[10].

Figure 4-3 – 2003 measurement campaign: Average EPS efficiencies

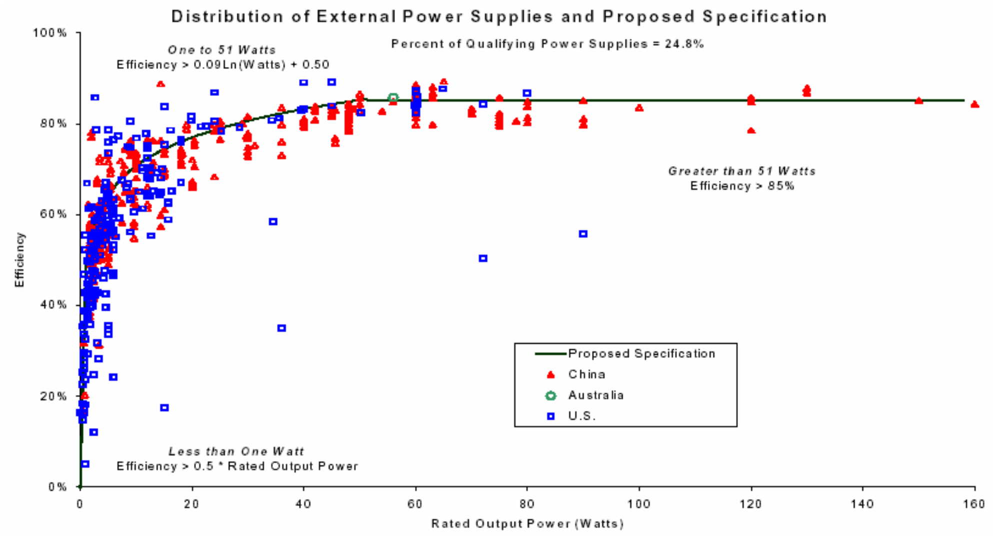
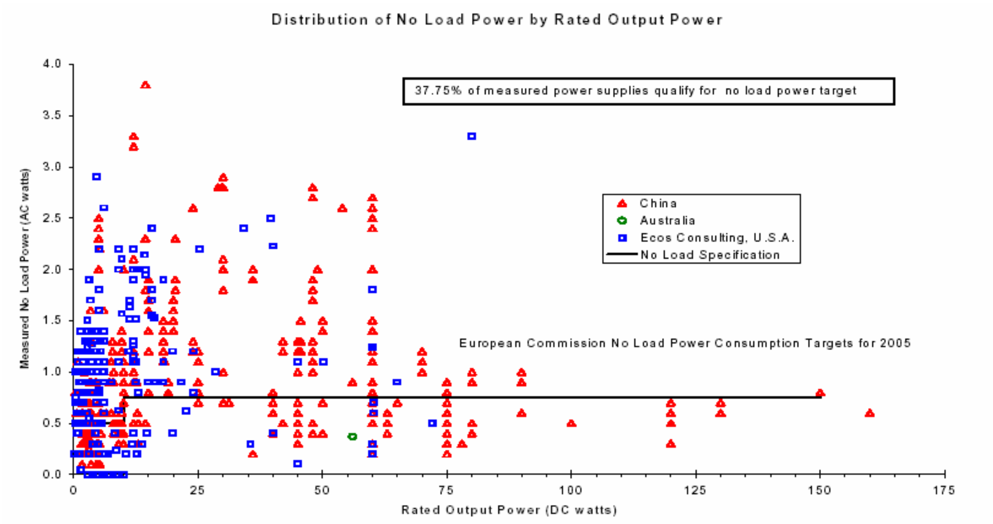


Figure 4-4 – 2003 measurement campaign: No-load losses



9 Zhang Guoqin: A Brief Introduction of the China External Power Supply Project, June 21, 2004, Beijing

10 Which is identical with the mandatory Californian requirements (CEC) for phase 2

For the 500 EPS measured in China in 2003, which are shown in the graphs above, average values are stated as follows (but without giving a correlation to rated output power)[11]:

- Linear power supplies
  - Efficiencies from 15 – 76%, average 49%
  - No load losses 0.35 – 3.8 W, average 1.02 W
- Switched-mode power supplies
  - Efficiencies from 17 – 88%, average 64%
  - No load losses 0.1 – 3.8 W, average 0.92 W

The background document for the Australian MEPS[12] evaluates the data from the above mentioned EPS testing in China, Australia and USA per wattage range and states average values as presented in Table 4-16.

Table 4-16 – 2003 measurement campaign: Average EPS efficiencies and no-load losses

Rated Output Power (P_{no}) (in watts)	Average Efficiency	Average no load power losses (in watts)
$0 < P_{no} \leq 2.5$	41%	0.70 W
$2.5 < P_{no} \leq 4.5$	55 %	0.71 W
$4.5 < P_{no} \leq 6$	59 %	0.90 W
$6 < P_{no} \leq 10$	64 %	1.02 W
$10 < P_{no} \leq 24$	69 %	1.39 W
$24 \leq P_{no}$	82 %	1.27 W

It has to be noticed, that – due to technical reasons – at the lower end of each output power class, efficiency is likely to be lower than the stated average and higher at the upper limit.

However, the market has changed since 2003. Especially the market share of (less efficient) linear power supplies is decreasing while the market share of switched-mode EPS is increasing. The market average as of 2006 is assumed to be better than that of the 2003 measurement campaign. The 2003 data can serve as a “worst case” assessment.

11 Zhang Guoqin (2004) A Brief Introduction of the China External Power Supply Project, June 21, 2004, Beijing

12 Marc Ellis & Associates (2004) Minimum Energy Performance Standards – External Power Supplies, The Australian Greenhouse Office under the National Appliance & Equipment Energy Efficiency Program Report No: 2004/07

EU Code of Conduct compliant products in 2005

External power supplies complying with the EU Code of Conduct can serve as a "best case" scenario as market leading products are – or at least are assumed to be – subject to the Code of Conduct rules.

The average no-load power and average efficiency of compliant products are as listed below (Table 4-17)[13].

Table 4-17 – 2005 CoC Compliant Products: Average EPS efficiencies and no-load losses

Rated Output Power (P_{no}) (in watts)	Average Efficiency	Average no load power losses (in watts)
$0 < P_{no} \leq 1.5$	-	-
$1.5 < P_{no} \leq 2.5$	59 %	0.17 W
$2.5 < P_{no} \leq 4.5$	62 %	0.16 W
$4.5 < P_{no} \leq 6$	64 %	0.15 W
$6 < P_{no} \leq 10$	-	-
$10 < P_{no} \leq 25$	76 %	0.21 W
$25 \leq P_{no}$	87 %	0.45 W

UK Conformance Testing 2005

The UK Market Transformation Programme investigated efficiency and no-load losses of EPS on the market compared to the requirements of the EU Code of Conduct, differentiating major market sectors[14]:

- Mobile phones

  The ten "top selling" mobile phones in the UK are served by four charger types with maximum rated output of 2.3 – 4.6 W, all of them with no load losses below 0.3 W and an average efficiency between 64% and 69%. The Code of Conduct criteria are exceeded by all tested mobile phone chargers.

- Personal audio equipment

  40% of external power supplies for MP3 and multi-media personal players meet the Code of Conduct criteria.

13 Hans-Paul Siderius (2006) Code of Conduct on Power Supplies, Results 2005, European Commission Joint Research Center, Ispra, March 8.

14 Market Transformation Programme (2005) CoC External Power Supplies, Conformance Testing Overview, Meeting on EU Code of Conduct on Energy Efficiency of External Power Supplies, 25 May.

- Cordless phones

  In 2005 on the European market, 90% of power supplies for DECT phones did not meet the efficiency average specified in the Code of Conduct.

- Digital Audio Broadcasting Radios

  Whereas power supplies for conventional radios on the UK market meet Code of Conduct requirements, 98% of the external power supplies for portable DAB radios do not meet the CoC standby and efficiency criteria “by a large margin”. The best selling portable radio in the UK has an average supply efficiency of 38% and a standby power consumption of 3 W.

- Laptops

  All 60 tested laptop power supplies (test campaign last quarter 2004 and first quarter 2005) met the standby criteria of the Code of Conduct and only very few (3) missed slightly the efficiency criteria.

ENERGY STAR compliant products in 2006

For ENERGY STAR compliant products, a listing with efficiency data is frequently published. These data can be seen as another “best case” assessment for the current market average as products with efficiencies lower than ENERGY STAR criteria are ruled out from these statistics per se.

Figure 4-5 shows the average efficiencies of ac-dc external power supplies as of May 2006[15]. The average ENERGY STAR compliant EPS come with an average efficiency at 2 W rated output power of 60%. 70% efficiency is the average for 6 W EPS, and above 15 W an efficiency of 86% is common. For comparison, the average data for the 2003 measurement campaign is shown in this graph as well. Further, Figure 4-6 shows the no-load losses of ENERGY STAR compliant products in 2006.

15 Qualified Product (QP) List for ENERGY STAR® Ac-Dc Qualified External Power Supplies, List Current as of May 30, 2006

Figure 4-5 – 2006 ENERGY STAR Compliant Products: Average EPS efficiencies (individual EPS)

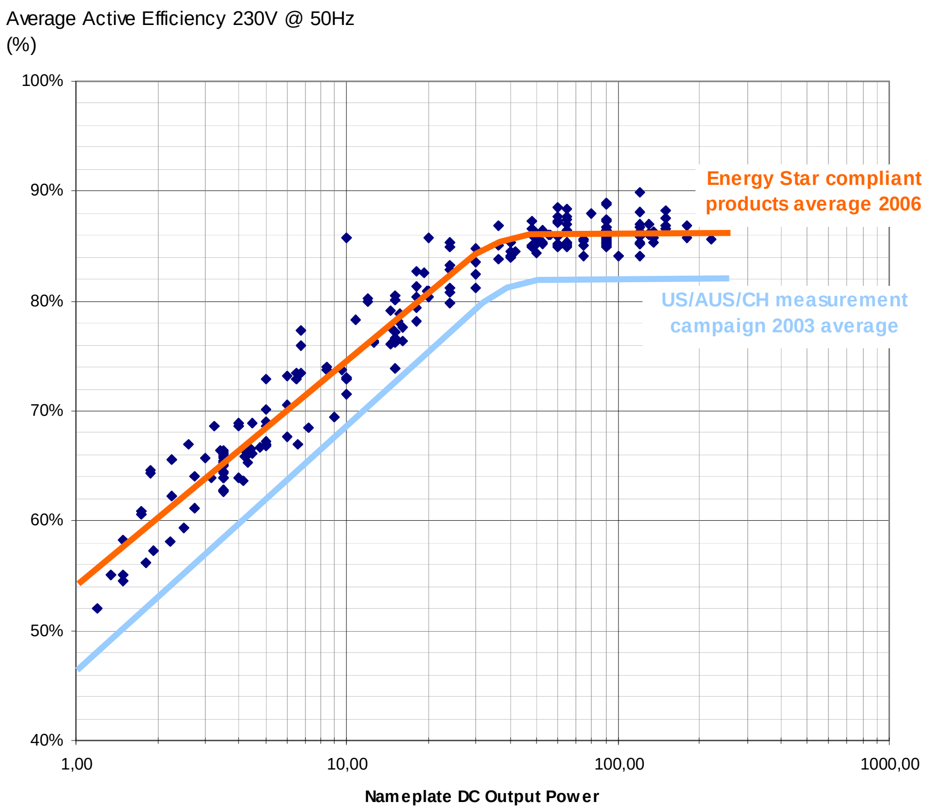
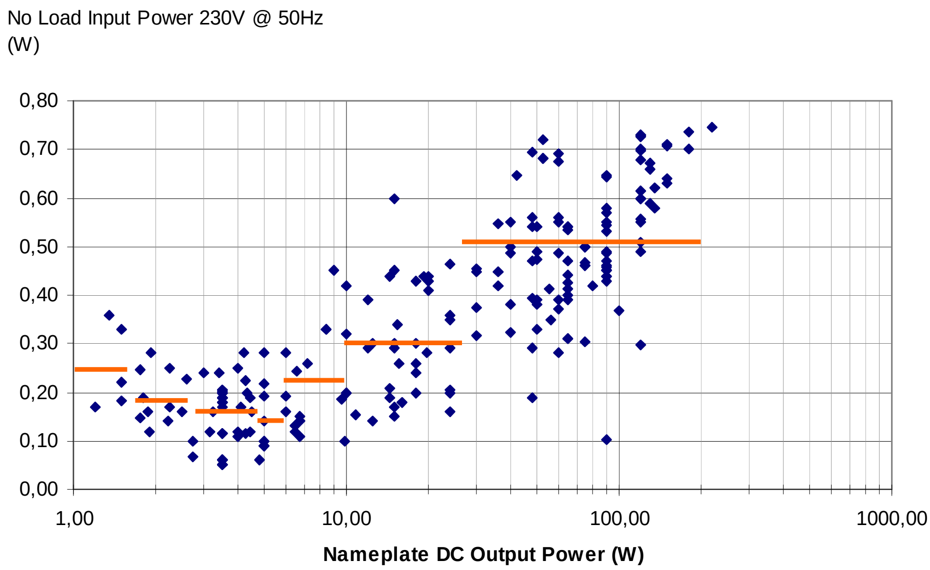


Figure 4-6 – 2006 ENERGY STAR Compliant Products: No-load losses (individual EPS and per rated output power range)



4.3.1.3 Assumptions for efficiency and no-load losses per power output (excluding halogen lighting transformers)

Based on the data cited above, the average efficiencies and no-load losses per the output power range can be estimated as listed in Table 4-18 and Table 4-19, respectively. It should be noted that these tables follow purely a classification based on maximum rated power output and do not differentiate application specific aspects in the market.

Table 4-18 – Overview on average EPS efficiencies

Rated Output Power (P_{no}) (in watts)	Average Efficiencies			
	"Best case" data		Assumption for EuP preparatory study	"Worst case" data
	ENERGY STAR compliant EPS, 2006	EU Code of Conduct compliant EPS, 2005		USA/AUS/CH measurement campaign 2003
$0 < P_{no} \leq 1.5$	55.0 %	-	**50 %**	41 %
$1.5 < P_{no} \leq 2.5$	60.9 %	59 %	**55 %**	
$2.5 < P_{no} \leq 4.5$	65.0 %	62 %	**60 %**	55 %
$4.5 < P_{no} \leq 6$	68.6 %	64 %	**63 %**	59 %
$6 < P_{no} \leq 10$	73.7 %	-	**70 %**	64 %
$10 < P_{no} \leq 25$	79.7 %	76 %	**75 %**	69 %
$25 \leq P_{no}$	85.1 %	87 %	**82 %**[16]	82 %

Based on the data from the UK Market Transformation Programme (see above), for **chargers for mobile phones,** efficiency higher than stated in the above table for the respective power ranges has to be taken into account. Base case calculations will be based on an average efficiency of **66%**.

The above given data on efficiencies is for AC-DC power supplies mainly. AC-DC power supplies, as used frequently for cordless phones, can usually come with higher efficiencies as they do not have the losses of the rectification stage. However, these are basically linear transformers and when considering the full power supply chain, the actual efficiencies (at the point of defined dc power supply, which is in the end-product, not at the interface power supply and end-product) are usually much lower.

16 Dell, being one of the market leaders in the laptop business, which is the major product segment in the power range > 25 W assumes an average efficiency of today's EPS in this segment of 80% [Markus Stutz, Dell: e-mail of Nov 1, 2006 and statement at technical meeting in Brussels, Oct 5, 2006]. As this is even below the data from the older 2003 measurement campaign in USA, Australia, and China, stating 82%, for plausibility reasons this 82% figure is taken for the calculations.

Table 4-19 – Overview on EPS no-load losses

Rated Output Power (P_{no}) (in watts)	Average No-load losses			
	"Best case" data		Assumption for EuP preparatory study	"Worst case" data
	ENERGY STAR compliant EPS, 2006	EU Code of Conduct compliant EPS, 2005		USA/AUS/CH measurement campaign 2003
$0 < P_{no} \leq 1.5$	0.25 W	-	**0.3 W**	0.70 W
$1.5 < P_{no} \leq 2.5$	0.19 W	0.17 W	**0.3 W**	
$2.5 < P_{no} \leq 4.5$	0.16 W	0.16 W	**0.3 W**	0.71 W
$4.5 < P_{no} \leq 6$	0.15 W	0.15 W	**0.3 W**	0.90 W
$6 < P_{no} \leq 10$	0.22 W	-	**0.3 W**	1.02 W
$10 < P_{no} \leq 25$	0.30 W	0.21 W	**0.4 W**	1.39 W
$25 \leq P_{no}$	0.51 W	0.45 W	**1.25 W**[17]	1.27 W

Furthermore, there is one technical aspect, which is in contradiction to the general technical trend that efficiency increases with rated output power: the power factor correction stage, which is mandatory from 75 W input upwards means additional losses. This effect cannot be quantified directly as there are no two EPS with exactly the same output power with and without PFC. Therefore only an indirect indication for this effect can be given based on the segment of ENERGY STAR compliant EPS with the highest rated output power but without PFC (65 W) and the corresponding neighbouring segment with lowest rated output power but with PFC (75 W): the average of the average efficiencies for the latter is 1 %-point lower than for the 65 W EPS average (85.3 % compared to 86.3 % based on 11 and 7 individual power supplies respectively). Regarding the no-load losses, the 65 W segment of ENERGY STAR compliant units has in average no-load losses of 434 mW compared to 456 mW for the 75 W segment. As the no-load power is expected to rise with the rated output power anyhow, it is not possible to quantify the effect of PFC on no-load losses in general. However, as a worst case estimate, the effect is assumed to be less than 30 mW.

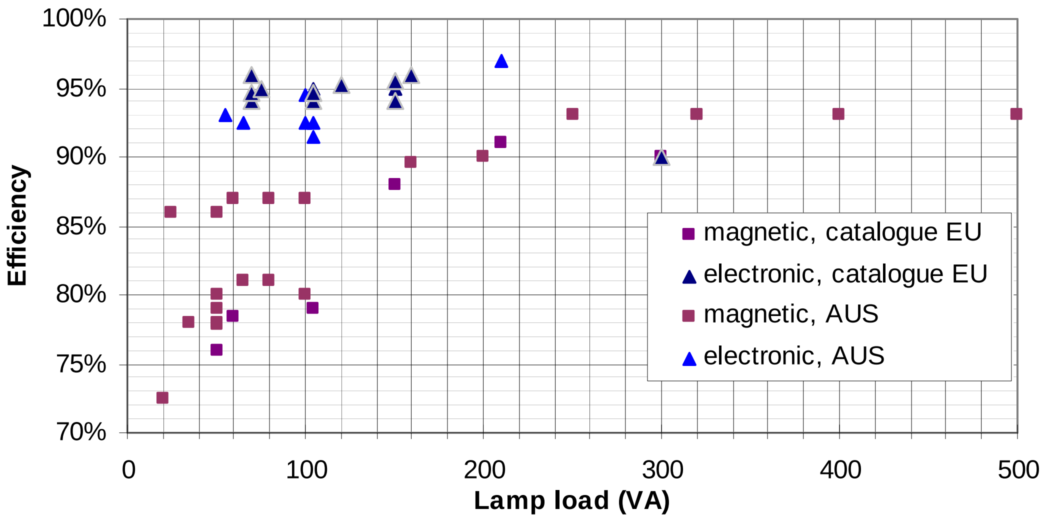
4.3.1.4 Data from statistics / measurement campaigns / compliance schemes for halogen lighting transformers

For halogen lighting transformers, retail catalogues frequently give efficiency data and losses under given lamp load respectively. From a background study

17 Stated by Dell as the most likely average [Markus Stutz, Dell: e-mail of Nov 1, 2006 and statement at technical meeting in Brussels, Oct 5, 2006]

for defining Australian MEPS, some further data are available based on lab testing and catalogue research as well[18]. A summary of these data is shown in the graph below (Figure 4-7), comprising data for 54 individual transformers.

Figure 4-7 – Efficiencies at full load for halogen lighting transformers



No-load losses for magnetic transformers have been tested by EPRI in 2004[19]: Corresponding to the basic physics of transformers measured no-load losses "are generally proportional to their full power rating". Magnetic transformers with a power rating of 20 VA exceed 2 W losses in no-load, 60 VA units are in the range of 4 W no-load losses.

For electronic transformers for halogen lighting no statistical data on no-load losses is available. Only data source is the product case referenced in section 4.3.2.

Product catalogues do not state no-load losses as individually sold transformers are meant to be used with a switch on the primary side.

4.3.1.5 Assumptions for efficiency and no-load losses per power output (for halogen lighting transformers)

Based on the data given above, the average efficiencies per power range can be estimated as listed in the following table.

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18 Mark Ellis & Associates, Steven Beletich Associates (2005) Analysis of the Potential for Minimum Energy Performance Standards for Power Supply Units for Extra Low Voltage Tungsten Halogen Lighting, Final Report. Data from this source is marked "AUS" in the following graph

19 Published in: Mark Ellis & Associates, Steven Beletich Associates (2005) Analysis of the Potential for Minimum Energy Performance Standards for Power Supply Units for Extra Low Voltage Tungsten Halogen Lighting, Final Report

Table 4-20 – Overview on full-load efficiencies for halogen lighting transformers

Rated Lamp Load (P) (in watts)	Full load Efficiencies Assumption for EuP preparatory study	
	Magnetic transformers	**Electronic transformers**
0 < P ≤ 60	**80 %**	**92.5 %**
60 < P ≤ 105	**84 %**	
105 < P ≤ 210	**90 %**	
210 < P	**92 %**	

4.3.1.6 EFFICIENCIES AND NO-LOAD LOSSES FOR BATTERY CHARGERS

For battery chargers there is no statistical data available regarding the power consumption in various modes of operation (charging, equalization, maintenance, no-load). It is not justified to take the average efficiencies as stated for the "pure" power supplies for battery chargers as well, as the chargers come with an additional circuitry for charging control etc., which results in additional power losses throughout the power supply chain[20].

As reflected by the Energy Star requirements for Battery Charging Systems there is a dependency of efficiencies in correlation with the voltage of the charged battery pack. For higher voltage cells the power losses in maintenance and no-load are relatively lower than for low voltage battery systems, such as single Ni-based cells.

For standard Ni-based battery chargers ETH Zürich has published data from an internal measurement campaign[21]. Figure 4-8 shows the total efficiency of different chargers depending on the loading times. Total efficiency is defined as the ratio of total power consumption during charging and the power delivered by the batteries charged (different capacities, batteries taken are those, which are sold together with the charger). This means the efficiency also reflects battery parameters, not only charger parameters. The loading time corresponds to the end-point indication by the charger itself. As a tendency, the charging cycle with fast chargers is more efficient than with slow chargers. An assumed reason for this trend is the fact that the slow chargers rather come with linear power transformation whereas the fast chargers use switch-mode technology. Furthermore, the longer the charging time the more relevant are the inherent bottom-line losses of the charger.

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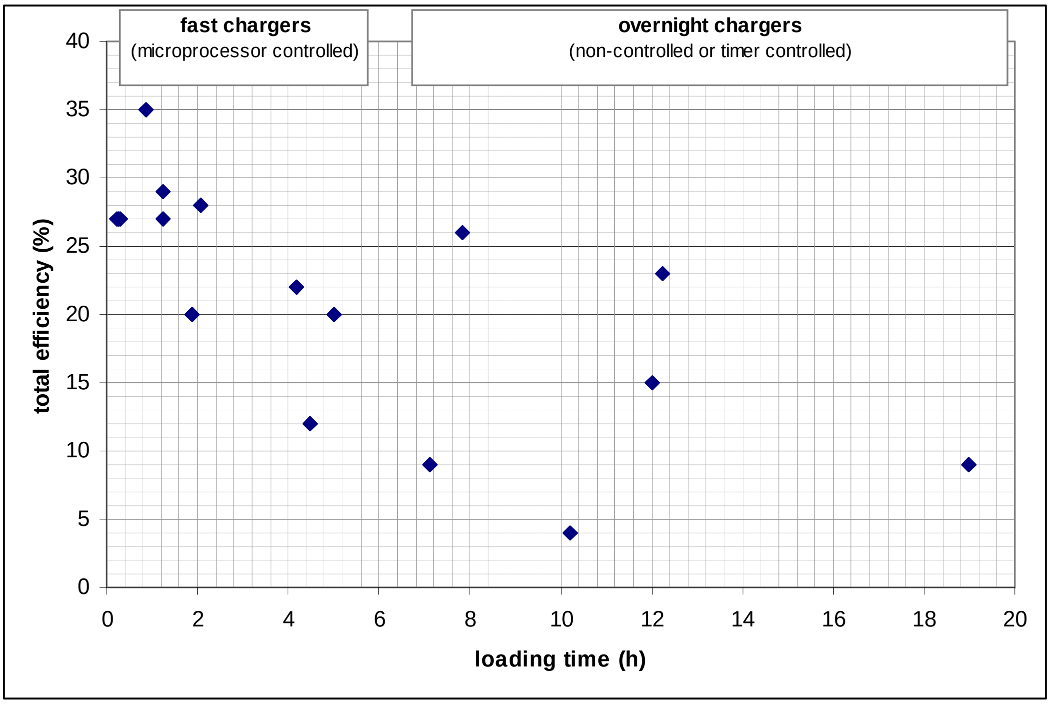
20 See the systems aspects below: from a system's perspective these charging losses occur also with other products, such as mobile phones and laptops, but in the end-device itself, not in the external unit.

21 Swiss Federal Institute of Technology Zürich, Electronics Laboratory: Test Ladegeräte, 2006 (http://www2.ife.ee.ethz.ch/~zinniker/batak/test06/lader/ladertest/index.html, viewed: 5.1.07)

Figure 4-8 – Total efficiency of battery charging with standard battery chargers



The no-load losses (no batteries inserted) of standard battery chargers vary widely according to the ETH data. For slow/overnight chargers the no-load losses range between 1.5 and 11.5 W, for fast (microprocessor controlled) chargers between 2 and 12 W. Average of 17 tested standard battery chargers is 5.6 W. These figures include the adaptors, where the charger comes with such an external adaptor (table top devices). The measured table top devices have average no-load losses of 7.9 W (adaptor and charger), whereas the chargers, which are plugged directly into the socket have in average no-load losses of 4.1 W. Obviously these integrated devices have an optimized transformer-charger-system usually.

The main source for energy consumption (and losses) for battery chargers for this study are the data given for the product cases (chargers for standard batteries and for power tools).

4.3.2 ANNUAL ELECTRICITY USE PER PRODUCT CASE

- **Mobile phone EPS**

The electricity consumption of a mobile phone product case in the use phase is calculated with an average efficiency of 66% and a load profile as defined in Task 3, consumer behaviour. The rated output power is calculated with 4 W, although EPS for mobile phones span the range between 2 and 5 W. Rated output power has a major influence on achievable efficiency (see statistics above), but as the trend is towards higher power output, it is appropriate to calculate with a 4 Watt EPS.

Table 4-21 – Use phase entries and resulting electricity consumption for the mobile phone EPS product case

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	3	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,00218939	kWh	0,799128788
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0,0003	kWh	1,095
217	Off-mode: No. Of hours / year	3650	#	
	TOTAL over Product Life	0,01	MWh (=000 kWh)	65

DECT phone EPS

The electricity consumption in the use phase is calculated with an average efficiency of 55% and the load profile as defined in task 3, consumer behaviour[22]. Once more, the fact has to be stressed that ac-ac power supplies might have efficiencies in the range of 65% and ac-dc linear power supplies with the same output power well below 50% average efficiency – but not the same functionality. The rated output power is calculated with 2.5 W.

Table 4-22 – Use phase entries and resulting electricity consumption for the DECT phone EPS product case

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	6	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,028125	kWh	10,265625
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,06	MWh (=000 kWh)	65

Digital camera EPS

The electricity consumption in the use phase is calculated with an average efficiency of 70% and a load profile as defined in task 3, Consumer behaviour[23]. The rated output power is calculated with the 6.5 W, which is the actual maximum output power of the exemplary EPS and represents this product segment adequately.

22 =((1/0.55)-1)*3*0.0025+((1/0.55)-1)*1*0.75*0.0025+((1/0.55)-1)*20*0.5*0.0025
23 =((1/0.70)-1)*(0.05*0.25*0.0065+0.25*1*0.0065)

Table 4-23 – Use phase entries and resulting electricity consumption for the digital camera EPS product case

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	3	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0.00073125	kWh	0.26690625
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0.0003	kWh	1.095
217	Off-mode: No. Of hours / year	3650	#	
	TOTAL over Product Life	0.00	MWh (=000 kWh)	65

Set-top box / Modem EPS

The annual electricity consumption in the use phase is calculated with an average efficiency of 70% for this power segment[24] and a load profile as defined in task 3, Consumer behaviour[25]. The rated output power is calculated with 8.45 W, which is the actual maximum output power for the exemplary EPS and represents this product segment adequately.

Table 4-24 – Use phase entries and resulting electricity consumption for the set-top box / modem EPS product case

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	3	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,04888929	kWh	17,84458929
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,05	MWh (=000 kWh)	65

Personal care product EPS

The electricity consumption in the use phase is calculated with an average efficiency of 63% for this power segment[26] and a load profile as defined in task 3[27]. The rated output power is calculated with 4.8 W, which is the actual maximum output power for the exemplary EPS and represents this product segment adequately.

24 Which is assumed for this power segment, but rather overestimates the efficiency of the (mainly) linear designs for this kind of application

25 =((1/0.70)-1)*(21*0.5*0.00845+3*1*0.00845)

26 The exemplary power supply taken for BOM calculations here actually has an average efficiency of approx. 65,5%

27 =((1/0.63)-1)*(22*0.25*0.0048+2*1*0.0048)

Table 4-25 – Use phase entries and resulting electricity consumption for the personal care product EPS product case

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	4	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,02114286	kWh	7,717142857
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,03	MWh (=000 kWh)	65

Standard battery charger for AA/AAA batteries

During the charge cycle the manufacturer states, on average, efficiency losses of 4 W, less for a smaller charger and more for larger one. With a charging time of 12.5 hours on average[28] and assumed 50 charging cycles annually (Task 3), this results in 2.5 kWh / year.

Furthermore, the charger is assumed to remain 2.75 hours per day in no-load mode with a loss of 2.3 W on average.

Table 4-26 – Use phase entries and resulting average electricity and battery consumption for Standard battery chargers for AA/AAA batteries

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	5	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,05	kWh	2,5
213	On-mode: No. Of hours, cycles, settings, etc. / year	50	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0,0023	kWh	2,308625
217	Off-mode: No. Of hours / year	1003,75	#	
	TOTAL over Product Life	0,02	MWh (=000 kWh)	65
	Heat			
218	Avg. Heat Power Output	0	kW	
219	No. Of hours / year	0	hrs.	
220	Type and efficiency (Click & select)			85-not applicable
	TOTAL over Product Life	0,00	GJ	
	Consumables (excl. spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0,8	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None

The batteries can be seen as “consumables”. However, the EuP EcoReport template does not allow this entry. It is assumed that with a charger, that allows

28 This actually includes the maintenance mode

to charge up to 4 batteries, actually 3 batteries on average are inserted; for the 2-battery charger the assumed average is 1.8. For a standard battery charger product case, this totals to 2.4 batteries per charging cycle, 120 charged batteries per year.

In the EcoReport template in line 222, a consumption of "0,8" is entered[29], the unit actually has to be "batteries/year" instead of "kg/year", the material "AA/AAA standard batteries".

Power tool charger

Based on the product case data provided by two leading power tools manufacturers, the power losses during battery charging times are roughly in the range of 12 – 16 W for both, switch-mode and linear transformer designs throughout the full power range relevant for power tools.

Maintenance power consumption is in the range of approx. 2.5 to 5.5 W for chargers with charging control and no-load losses in a similar range. These high no-load losses result from the fact that the secondary side charging control needs some energy to operate and this power is provided by the same converter which has to deliver the power for the charging itself.

Charging times for professional power tools and frequently also for DIY tools is in the range of 0.5 to 1.5 h for the convenience of the user. However, there are also DIY tools which can rather be considered overnight chargers with much longer charging times, and no charging control – which results in high power consumption in "maintenance mode", but lower power consumption in no-load as there is no charging circuitry, which needs constant power supply.

The following settings are assumed for power tools as conscious abstraction of reality[30]:

- Charging time: 1 hour
- Power losses in charging mode: 15 W
- Maintenance power consumption: 4 W
- No-load losses: 4 W

For DIY tools based on a technology without dedicated charging control, maintenance power might be in the range of 7 W, no-load losses in the range of 1 W – but this does not have in influence on the total annual power consumption for the given use profile.

The entries for both professional and DIY tools are listed in the table below, but notice the following nomenclature: "On-mode" = battery charging mode; "Standby-mode" = maintenance / trickle-charge; "Off-mode" = no-load.

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29 Based on the ratio charging cycles (uses of the charger): battery lifetime (charging cycles) of 120: 150

30 These assumptions result in following power consumptions in detail: Professional tools - Charging: 1 h * 500 cycles * 15 W = 7500 Wh / Maintenance: 1 h * 500 cycles * 4 W = 2000 Wh / No-load: 2 h * 365 days * 4 W = 2190 Wh / Total per year: 11690 Wh; DIY tools - Charging: 1 h * 5 cycles * 15 W = 75 Wh / Maintenance: 1 h * 5 cycles * 4 W = 20 Wh / No-load: 0,02 h * 365 days * 4 W = 22 Wh / Total per year: 117 Wh

Table 4-27 – Use phase entries and resulting average electricity consumption for professional power tools charger

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	2	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0.015	kWh	7.5
213	On-mode: No. Of hours, cycles, settings, etc. / year	500	#	
214	Standby-mode: Consumption per hour	0.004	kWh	2
215	Standby-mode: No. Of hours / year	500	#	
216	Off-mode: Consumption per hour	0.004	kWh	2.92
217	Off-mode: No. Of hours / year	730	#	
	TOTAL over Product Life	0.02	MWh (=000 kWh)	65

Table 4-28 – Use phase entries and resulting average electricity consumption for DIY power tools charger

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	7	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0.015	kWh	0.075
213	On-mode: No. Of hours, cycles, settings, etc. / year	5	#	
214	Standby-mode: Consumption per hour	0.004	kWh	0.02
215	Standby-mode: No. Of hours / year	5	#	
216	Off-mode: Consumption per hour	0.004	kWh	0.0292
217	Off-mode: No. Of hours / year	7.3	#	
	TOTAL over Product Life	0.00	MWh (=000 kWh)	65

- **Printer EPS**

The electricity consumption in the use phase is calculated with an average efficiency of 75% and a load profile as defined in Task 3[31]. The rated output power is calculated with 17.5 W. This is the average of the two “real-world” EPS, on which this assessment is based (specified for 15 and 20 W respectively, very common ratings for printer EPS).

31 =((1/0.75)-1)*(23.9*0.25*0.0175+0.1*1*0.0175)

Table 4-29 – Use phase entries and resulting electricity consumption for printer EPS

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	4	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,035438	kWh	12,9346875
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,05	MWh (=000 kWh)	65

Transformer for halogen lighting (magnetic)

The annual electricity consumption in the use phase is calculated with an average efficiency of 80%. No-load losses are not taken into account for the base case calculation. This refers to a scenario, where the switch is placed on the primary side of the transformer. An exemplary calculation for a scenario with no-load losses (e.g. desktop halogen lamp with a transformer, which has to be plugged into the socket) is given in the Environmental Impact Assessment (based on 4 W no-load losses, 16 hours per day).

The rated output power is calculated with 60 W, which is a very common transformer output power for halogen lighting. Assumed lifetime 10 years and 8 hours per day under 100% load[32].

Table 4-30 – Use phase entries and resulting electricity consumption for an average halogen lighting transformer (magnetic)

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	10	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,12	kWh	43,8
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,44	MWh (=000 kWh)	65

Transformer for halogen lighting (electronic)

The annual electricity consumption in the use phase is calculated with an average efficiency of 92,5%. No-load losses are not taken into account for the base case calculation which refers to a scenario, where the switch is usually placed on the primary side of the transformer. The rated output power is calculated with 60 W, which is a very common transformer output power for

32 =((1/0.8)-1)*0.06*8

halogen lighting. Assumed lifetime is 10 years, with 8 hours per day under 100% load[33].

As with the magnetic transformer, the Environmental Impact Assessment will reference an alternative scenario, where the switch is placed on the secondary side (wall adapter transformer) and no-load matters. Based on measurements undertaken for the exemplarily chosen electronic transformer[34], no-load losses of 0,2 W are taken as reference value for the calculation. The no-load losses of electronic transformers in contrast to magnetic ones do not correlate with the output power[35].

Table 4-31 – Use phase entries and resulting electricity consumption for an average halogen lighting transformer (electronic)

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	10	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,03891892	kWh	14,20540541
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	0,14	MWh (=000 kWh)	65

Laptop EPS (65 W)

The annual electricity consumption in the use phase is calculated with an average efficiency of 82%, no-load losses of 1.25 W and a load profile as defined in task 3, Consumer behaviour[36].

Table 4-32 – Use phase entries and resulting electricity consumption for an average laptop EPS (65 W)

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	5	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,10344512	kWh	37,75746951
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0,00125	kWh	6,159375
217	Off-mode: No. Of hours / year	4927,5	#	
	TOTAL over Product Life	0,22	MWh (=000 kWh)	65

33 =((1/0.925)-1)*0.06*8

34 As this specific product is sold for mounting it in lighting installations, not as wall adapter, this transformer design has not been optimized for no-load losses. In principle, the electronic circuitry for transformers for installations and wall adapters is the same, only connectors / housing differ.

35 Measurements for a 100 W electronic transformer from the same manufacturer resulted in nearly the same no-load losses of 0,2 W

36 =((1/0.82)-1)*(1*0.25*0.065+4*0.5*0.065+2*0.75*0.065+3.5*1*0.065)

Laptop EPS (90 W)

The annual electricity consumption in the use phase is calculated with an average efficiency of 82%, no-load losses of 1.25 W[37] and a load profile as defined in task 3, Consumer behaviour[38].

Table 4-33 – Use phase entries and resulting annual electricity consumption for an average laptop EPS (90 W)

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	5	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,14323171	kWh	52,27957317
213	On-mode: No. Of hours, cycles, settings, etc. / year	365	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0,00125	kWh	6,159375
217	Off-mode: No. Of hours / year	4927,5	#	
	TOTAL over Product Life	0,29	MWh (=000 kWh)	65

4.4. USE PHASE (SYSTEM)

The purpose of this section is to analyse the system in which external power supplies and battery chargers operate. Systems analysis is important in order to understand the context in which EPS and chargers are embedded. The system can e.g. set technical requirements to the appliances and thus restrict the product design.

External power supplies and dedicated battery chargers (sold with/for an end-appliance) are not used as stand-alone products. They are always part of a system and the system determines to a large extend the specification for the EPS/BC – affecting also the technical solutions implemented in the EPS to comply with the system requirements - which makes EPS/dedicated BC different from most end-appliances. Standard BC can be considered stand-alone products, but even in this case the batteries, the "consumables", set requirements for the technical specifications.

For EPS, the product system comprises, on the **output side,** of the end-appliance, which runs on the energy delivered through the external power supply. The power requirements of the end-appliances determine the specification and major part of the use patterns of the EPS. If the EPS directly controls the charging of the batteries of the end-appliance, battery characteristics also play a role. If charging control is performed in the end-appliance, the battery is just one power consumer among others in the end-appliance.

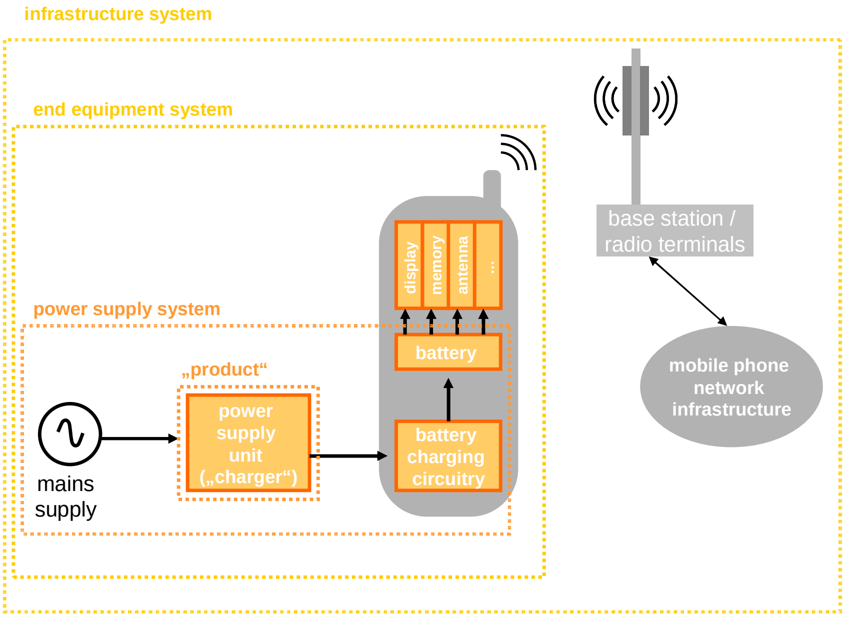
37 Notice that this is a conscious abstraction of reality for this power segment. But the exemplary BOM is correlated with an EPS with an average efficiency of 85.2% and no-load losses of approx. 0.6 W.

38 =((1/0.82)-1)*(1*0.25*0.09+4*0.5*0.09+2*0.75*0.09+3.5*1*0.09)

For battery chargers, the output side of the system comprises of the batteries. In the case of dedicated battery chargers, which are sold with/for an end-appliance, the output side system extends to the end-appliance. It is this appliance that determines the battery characteristics and thus indirectly the specifications of a chargers. The end-appliance also affects the user phase parameters of a dedicated charger.

In a broader sense, the overall product system is not made up only by the end-appliance. Some kind of infrastructure on which the end-appliance depends on also belongs to it: In the case of an EPS for a mobile phone, it is not only the operation of the mobile phone itself which determines how much energy the EPS is supposed to deliver. Also the mobile network plays a role. The transmitting power of the radio base stations has an influence on the power consumption of the mobile phone itself and consequently the amount of energy that has to be supplied through the EPS for charging (e.g. more or less frequent charging). The effect of these aspects could be significant (see Figure 4-9); nevertheless, they are out of scope of this system analysis as EPS/BC design cannot influence such network / infrastructure aspects.

Figure 4-9 – Illustration of different system levels: mobile phone charger example



An external power supply is, in almost all cases, only one part of the **overall power supply system** of any kind of electronic equipment: Usually, different sections / sub-assemblies / components within an end-appliance have different power requirements, especially regarding voltage. Consequently, the power supplied by the EPS needs further transformation within the end equipment to serve e.g. multiple voltage requirements. For the efficiency of the whole power supply system, the EPS is only one factor, other efficiency losses are caused by internal power transformation.

On the **input side**, the interaction with the mains supply is a major system aspect, when it comes to harmonics.

4.4.1 MAINS SUPPLY REQUIREMENTS

As a result of the peak rectification techniques applied for power supplies, harmonic currents are generated. These harmonics are of concern to the power generator and contribute to the apparent power, which has to be provided by the mains supply: More current has to be generated at source to deliver the power to the load, meaning less efficiency of energy transfer from source to load. Therefore, **power factor correction (PFC)** is required for devices / power supplies, which have an input wattage of 75 W.[39] This power factor correction needs additional components in the power supply unit. In principle, two main solutions are available for power supplies[40]:

- Passive power factor correction
- Active power factor correction

Passive PFC needs a line frequency inductor in the AC line. Active PFC is based on a boost converter running at high frequency to electronically control the wave-shape of the input current. Table 4-34[41] compares the two options.

Table 4-34 - Comparison between passive and active PFC

Advantages	Disadvantages
Passive PFC	
▪ Simple ▪ Cost effective (production costs) ▪ Rugged and reliable ▪ Low noise (electro-magnetic interference) ▪ Assists filtering	▪ Heavy and bulky components in case of high-power ratings (which, however, are an issue rather for internal than for external EPS) ▪ Low power factor
Active PFC	
▪ High power factor >0.9 ▪ Low input current	▪ High cost ▪ High complexity ▪ High component count ▪ Lower calculated MTBF (mean time before failure)

Another system aspect of the mains supply is the plug system. This has a certain, minor influence on the material consumption (different plug layout), but this is considered a negligible aspect.

4.4.2 END-APPLICATION REQUIREMENTS (EPS SPECIFICATION)

An EPS specification (no chargers) usually comprises the following parameters and thus determines the basics of the EPS design:

39 IEC 61000-3-2: Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)

40 Gary Bocock (Ed.) (2005) Power Supply Technical Guide, XP Power plc.

41 Adapted from [Gary Bocock (Ed.): Power Supply Technical Guide, XP Power plc 2005]

Technical data

- current direction (ac or dc)
- (maximum) output power
- output voltage
- tolerance of output voltage
- line regulation: static performance measure of how well a power supply holds the output voltage constant in the face of a changing input voltage
- load regulation: static performance measure, which defines the ability of a power supply to remain within specified output limits for a predetermined load change
- output current
- ripple voltage
- EMC aspects (compliance with standards)

Environmental conditions

- working temperature
- humidity
- over voltage resistance (compliance with standards)

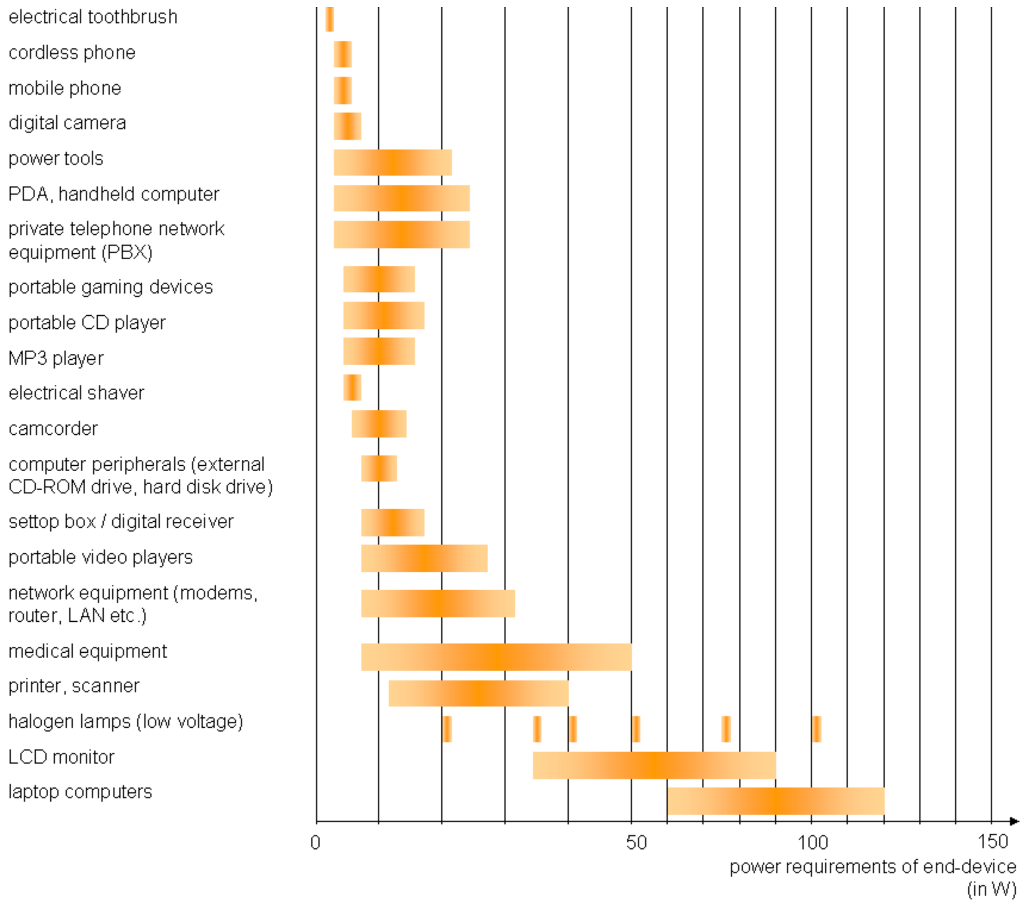
Other aspects

- safety (compliance with standards, for applications in the medical sector specific standards have to be met)
- lifetime / reliability (in “mean time before failure” – MTBF)

For system analysis, mainly the technical data is of relevance as these are the requirements from the system component “end equipment”.

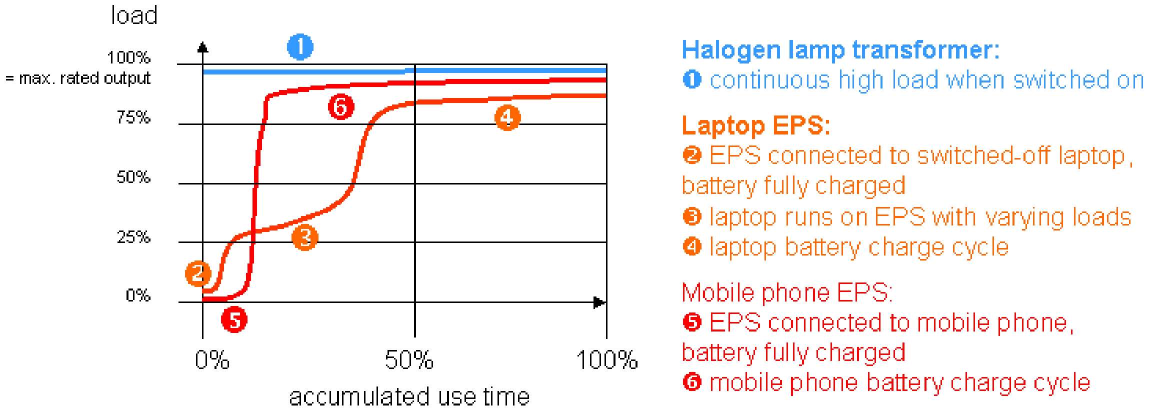
Output power ranges for major end-applications are shown in Figure 4-10 below. However, individual products for the given product categories might be out of the given range. Medical equipment for example comprises a larger variety of devices, very few of them even in the range above 100 W. For halogen lamps only the most common wattages are given.

Figure 4-10 – Power requirements of electrical and electronic equipment running on EPS



Although the maximum rated output power of an EPS is an outstanding specification parameter it has to be acknowledged, that most EPS most of the time run at partial load only. Such exemplary load profiles (percent of maximum rated output load over accumulated use time) are shown in Figure 4-11. The load profiles strongly depend on usage patterns; however, some principle distinctions as shown for halogen lamp transformer, laptop EPS and mobile phone charger give a clear indication of relevant use modes per application. (Notice: times while the EPS is disconnected from the end equipment are not shown in Figure 4-11)

Figure 4-11 – Exemplary load profiles for halogen lamp transformer, laptop EPS and mobile phone EPS



Regarding the **current direction** almost all relevant end equipments run on direct current (dc). There are only a few exemptions, such as halogen lamps: For these it doesn't matter, whether they are powered by direct current (dc) or alternating current (ac).

The switching technology causes **ripple voltage and noise** at the output. Pulse width modulation and switching are the main reasons for these effects. Usually the specification – based on end equipment requirements – limits the maximum acceptable ripple and noise. Besides costs, linear power supplies have the main advantage to meet the extremely low noise requirements of some specific applications, such as audio devices.

Galvanic isolation for security reasons is another function of external power supply units from the system's point of view: As the transformer provides isolation from the 230 Vac input, the end equipment is protected from high voltage and needs to be qualified for the lower output voltage of the EPS only.

The **voltage** requirements of the end equipment have to be met by the power supply unit, although further voltage regulation usually is performed by dc-dc converters internally. Typical output voltage requirements for external power supplies are between a few volts and up to 24 V. Output voltage is an important issue for efficiency considerations as low output voltages due to technical reasons tend to be less efficient than EPS with higher output voltages[42]. From a system perspective this aspect is an important one as the efficiency of EPS might be better, if higher voltage is supplied to the end equipment and regulated to a lower level internally, but for the whole power supply system the efficiency might be worse.

The end equipment is designed to operate at a certain input voltage. The external power supply has to **protect the end equipment** against over-voltage.

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42 TIAX LLC (2006) Assessment of Analyses Performed for the California Energy Efficiency Regulations for Consumer Electronics Products, Cambridge, MA, USA, Feb. 2, 2006, pp 30-31.

To do so, circuits are needed, which limit the current or power supplied by the EPS in case of an overload or short circuit on the output (end equipment) side. Technical options for overload protection are[43]:

- constant power limit
- constant current limit
- trip & restart mode (not appropriate for battery-charging applications)
- fold-back current limit (usually used in linear power supplies)

Some EPS requirements are specific for certain applications. These end equipment specifications are outlined in the following paragraphs.

4.4.2.1 Transformers for halogen lamps

Due to the characteristics of halogen lamps, a so-called **soft-start** is needed for an enhanced lamp life: The filament of the halogen lamp has a positive temperature coefficient of resistance such that the resistance at switch-on is much lower than under continuous operation with a heated filament. This normally would cause a high inrush current to occur at switch-on, which affects adversely the circuitry of the transformer but even more the lamp itself. Therefore, transformers for halogen lamps preferably should be equipped with a soft-start function.

Another specific, but optional requirement for halogen lamps is a **dimming** function, which needs a corresponding specification of the transformer. For some halogen lamps, e.g. floor standing lamps, the transformer and the dimmer come as one part.

4.4.2.2 High moisture application environment

Recharging batteries in areas of **high moisture**, such as the bathroom, is critical. Therefore, e.g. electric toothbrushes are charged by inductive chargers. No direct electrical contact between battery and charger is needed. However, this charging technology is not very energy efficient.

4.4.3 Battery charging

The batteries used in applications relevant for external power supplies are

- Nickel-Cadmium (NiCd)
- Nickel-Metal-Hydride (NiMH)
- Lithium-Ion (Li-Ion)
- Lithium-Polymer
- Lead-acid

43 Gary Bocock (Ed.) (2005) Power Supply Technical Guide, XP Power plc

The unique needs of these different battery types need to be matched with the charger characteristics as improper handling or an inadequate charging process affects lifetime in general (number of charging cycles) and properties of battery over lifetime. The following table summarises the general needs of the different battery types regarding handling and charging process and an overview on charge methods (Table 4-35)[44]. Charging control methods for the different battery types are further described in the following paragraphs.

Table 4-35 – Battery charging requirements and battery end-applications

Battery type	Handling and charging needs	charging methods	cycle life (to 80% of initial capacity)	exemplary applications
NiCd	▪ battery has to be discharged fully before charging ▪ removal of battery from charger after charging (within 2 days) because of memory effect ▪ overheating of battery during the charge cycle to be avoided	▪ constant current, followed by trickle charge when full ▪ fast charge preferred over slow charge ▪ slow charge: 16 hours, rapid charge: 3 h, fast charge: 1 h	1.500	▪ shaver ▪ headphone stereo systems ▪ CD players
NiMH	▪ removal of battery from charger after charging (within 2 days) because of memory effect ▪ overheating of battery during the charge cycle to be avoided	▪ constant current, followed by trickle charge when full ▪ slow charge not recommended ▪ rapid charge: 3 h, fast charge: 1 h	300 - 500	▪ power tools including drills and saws ▪ toys
Li-Ion	▪ battery lasts longer with partial rather than full discharges ▪ no memory effect (battery may remain in the charger)	▪ constant voltage to 4.2V/cell (typical) ▪ no trickle charge when full ▪ no fast charge possible ▪ rapid charge: 3 h	500 – 1.000	▪ laptop ▪ mobile phone ▪ portable CD Players ▪ PDA
Li-Polymer	▪ charging cycle has to be controlled thoroughly (overcharging leads to destruction) ▪ temperature sensitive ▪ no memory effect (battery may remain in the charger)	▪ constant current / constant voltage charging ▪ no trickle charge when full ▪ no fast charge possible ▪ rapid charge: 3 h	300 – 500	▪ laptop ▪ mobile phone

44 Compilation of handling and charging needs and charging methods is based on [Gary Bocock (Ed.) (2005) Power Supply Technical Guide, XP Power plc], cycle lives are given by [Isidor Buchmann (2001) Batteries in a Portable World]

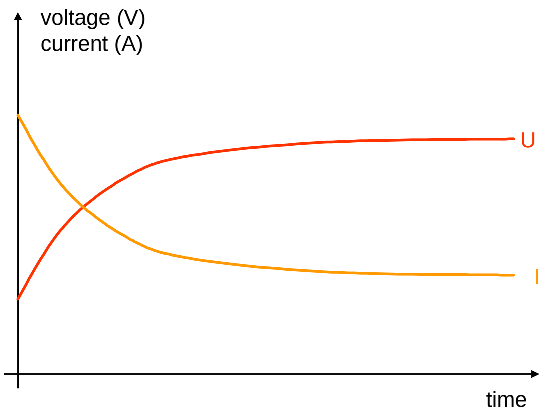
Battery type	Handling and charging needs	charging methods	cycle life (to 80% of initial capacity)	exemplary applications
Lead-acid	▪ Lead-acid must always be kept in a charged condition ▪ Battery lasts longer with partial rather than full discharges	▪ constant voltage to 2.4 V/cell (typical), followed by float held at 2.25 V/cell ▪ no fast charge possible ▪ slow charge: 24 h, rapid charge: 10 h	200 - 300	▪ starter batteries ▪ cleaning equipment ▪ electric vehicle ▪ mobile lighting ▪ measurement equipment ▪ photo equipment

Battery self discharge rates are an important element regarding the total energy consumption of charger-battery systems. For example, the newly launched low self discharge NiMH batteries (Panasonic Infinium, Uniross Hybrio, Ansmann Max e, Sanyo Eneloop, GP Recyko) keep around 80% of the stored energy for up to 1 year and after 2 years around 50% of the charged energy is still in them. If these batteries are used in combination with microprocessor chargers, the use of energy is limited to a minimum: when batteries are charged again after 1 year storage, they still contain 80% of the charge which will be detected by the microprocessor controlled charger and consequently it will only charge the missing 20%; this will lead to a very short charging cycle and thus low energy use. The wider spread of such technology could lead to major energy reduction in all categories where these batteries can be used either as single cells (digital still camera, toys, audio equipment) or in packs for cordless power tools, cordless phones and other appliances which can work with combinations of NiMH batteries.

4.4.3.1 NICD AND NIMH CHARGING CONTROL

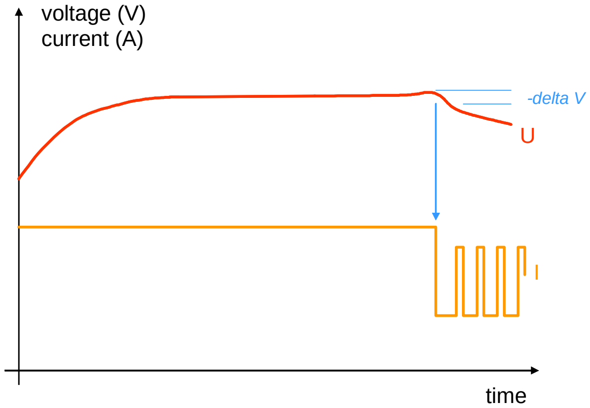
Standard charging for NiCd and NiMH without any specific mechanism to control the charge status of the battery pack is based on a charging curve with decreasing charging current as the battery pack voltage increases (Figure 4-12). The final charging current needs to be specified in a way, that it does not exceed the value acceptable for the battery pack as a continuous charge.

Figure 4-12 – Standard charging process for NiCd and NiMH batteries



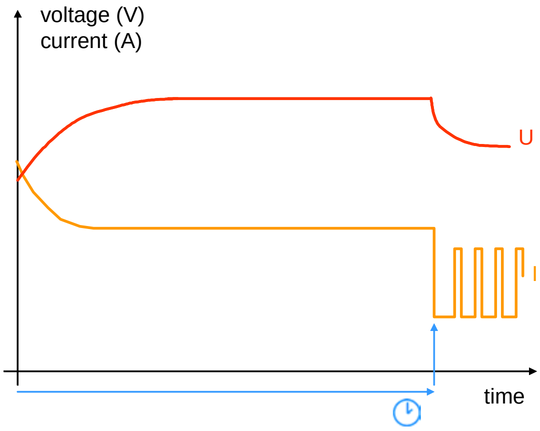
For fast charging the **–delta V detection** technology is recommended for NiCd batteries: A switch-over from fast charge to trickle charge is initiated by –delta V detection, which signals full charge of the battery (Figure 4-13).

Figure 4-13 – Charging for NiCd and NiMH batteries based on –delta V detection



Another option for charging control is **timer control**. In this case the charger has to be designed for specific battery pack characteristics. Fast charging current and time for a charging cycle, from fully discharged to fully charged, are known for a given capacity. Through a timer the charging process changes over to trickle charge after this time has elapsed (Figure 4-14). This process requires loading fully discharged batteries only.

Figure 4-14 – Charging for NiCd and NiMH batteries based on timer control

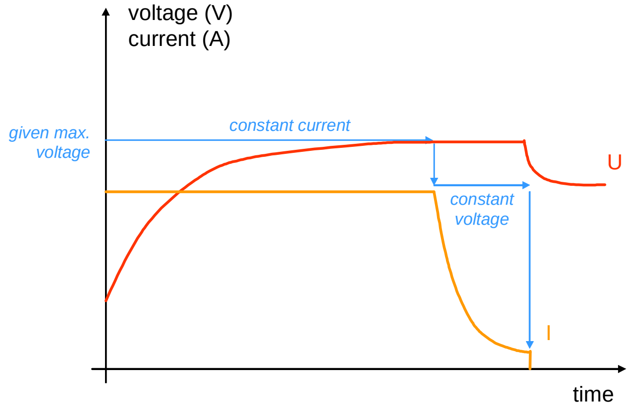


4.4.3.2 Li-Ion and Li-Polymer charging control

For Li-Ion and Li-Polymer cells **constant current / constant voltage control** is applied (Figure 4-15): The battery is charged at a set current level until it reaches its final voltage, which is usually 4.2 V for Li-Ion cells. At this point, the charger circuitry switches over to constant voltage mode, whereas the current drops to hold the battery at this final voltage. The charging current is switched off once it has dropped to the default value of the cell.

The charging cycle has to be thoroughly controlled to maintain full capacity, but avoiding overcharging, which easily destroys the Li-Ion battery. Overcharging by more than +1% could result in battery failure, whereas undercharging results in reduced capacity.

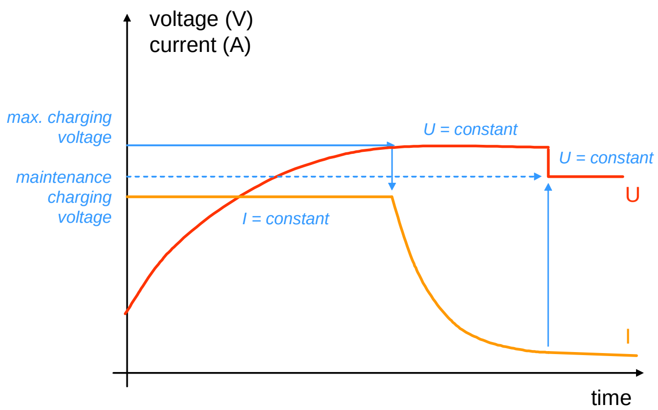
Figure 4-15 – Charging for Li-Ion and Li-Polymer batteries based on CCCV control



4.4.3.3 LEAD-ACID CHARGING CONTROL

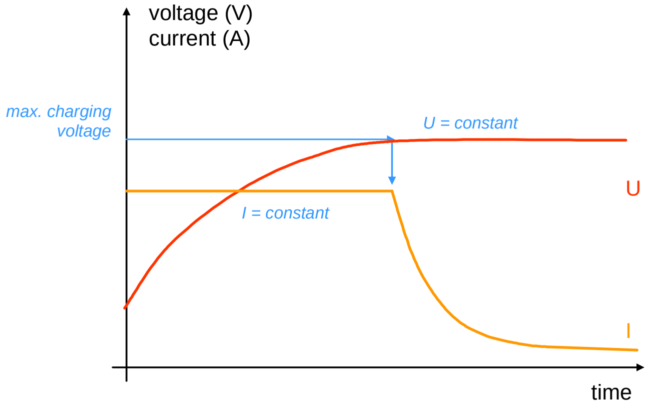
The **IUoU control** of a lead-acid battery is performed in two stages: In the first stage the battery voltage rises to a predefined value while the current remains constant (I constant). When reaching the temperature-linked gassing voltage the post-charging phase begins: The voltage is maintained constant (U constant) and charging current decreases until the battery is fully charged. Thereafter the maintenance charging (U constant on lower level) follows to compensate self-discharge of the battery (Figure 4-16).

Figure 4-16 – Charging for lead-acid batteries based on IUoU control



The most common charge control method for lead-acid batteries is **IU control**: A constant current flows until the specified end charge voltage is reached (I constant). While the voltage remains constant (U constant) the current decreases to the trickle charge level (Figure 4-17). IU control is applied preferably for lead-acid batteries used for stand by and parallel use.

Figure 4-17 – Charging for lead-acid batteries based on IU control

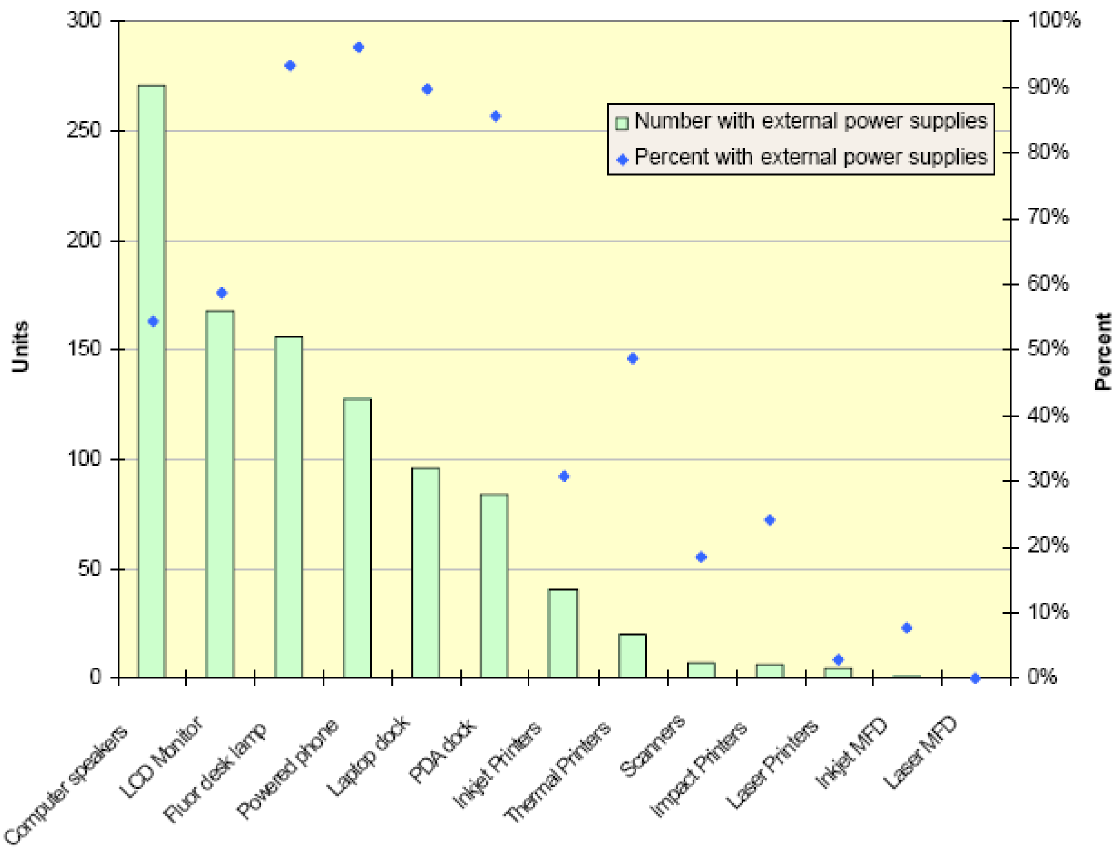


4.4.4 INTERNAL VS EXTERNAL POWER SUPPLIES

In several cases, there is in principal the option either to use an external or an internal power supply unit. Such an example are LCD monitors, which come either with an external power supply unit or with an internal one. Also for low voltage halogen lamps some products come with external power supplies, but others – where the product design allows an integration of the power supply unit, e.g. in the lamp base – are available also with integrated ones.

The findings of a recent office census (see Figure 4-18) illustrates how some appliances, such as 'powered phone', are dominantly powered by EPS, while other appliances have EPS in 20-50% of the cases and yet others never have an EPS. It should be noted that the fluor (fluorescent) desk lamp "EPS" in the figure are actually ballasts, which are not in the scope of this study.

Figure 4-18 – LBNL Office Census Findings in California, Pennsylvania, and Georgia[45]



The variant with the external power supply is in the scope of this study, whereas the variant – same performance, system and power supply specification – with internal power supply is not in the scope. Consequently, in case of generic or specific requirements for EPS an integration of the formerly external power supply unit could be a design strategy to fall out of the scope of such requirements.

4.4.5 ALTERNATIVE SYSTEMS

In some cases on the system level there are alternatives to the use of external power supplies – besides the above mentioned case, where external ones can be replaced by internal power supply units:

- **Lamps:** An alternative to low-voltage halogen lamps, which need an EPS to transform down the voltage are high-voltage halogen lamps, which are directly powered from the mains supply at 230 Vac. In principle, there are also other lighting systems, which could be used instead of halogen lamps in general, such as traditional light bulbs or fluorescent lamps with ballasts

45 PG&E (2004) Analysis of Standards Options for Single-Voltage, External AC to DC Power Supplies – CASE Project. California.

(see Table 4-36 for an overview on most common lighting technologies). If such shifts lead to overall improvements of environmental performance is out of scope of this product group study and should be clarified by the preparatory studies on lighting.

Table 4-36 – Lighting technologies

Lighting technology	main fields of application	Relevance for product category EPS
Incandescent	Residential lighting	no EPS
Compact fluorescent	Residential lighting	ballasts covered by 2000/55/EC
Tubular fluorescent	Industrial and office lighting	ballasts covered by 2000/55/EC
Halogen	Retail / display lighting	options: with EPS (low-voltage) lamp system with integrated power supply no power supply unit (high-voltage)
High-Intensity Discharge (HID)	Outdoor lighting	mainly fixed installations with power supplies
Light-emitting diode (LED)	Emergency lighting, traffic lights	mainly fixed installations with integrated power supplies, but might enter segments of halogen lamps in the future

- **Device integration:** Some (peripheral) devices, which come with an external power supply can be integrated in the main device, being powered then from the internal power supply of the main device. Such examples are modems, external CD-ROM drives, external hard disk drives, which could be integrated – with certain constraints regarding costs, modularity, functionality and space – also in the Personal Computer or laptop. The laptop is even a special case, as the laptop EPS now has to provide also the power to the formerly external peripherals.
- **USB-port powered devices:** USB-powered devices lead to a system's change from external power supplies to powering by the computer (see the document on Task 2 related to market data and trends for details). The power supply systems in case of USB-powering comprises e.g. in case of a mobile audio equipment connected to a laptop the external power supply of the laptop, the laptop's battery, laptop internal dc-dc conversion, power transmission to the connected mobile audio equipment and charging of the audio equipment's battery. Although there is no data for the efficiency of such a power supply system it is very likely just by considering the usual losses of the aforementioned system components, that USB-powering is much more inefficient than power supply by a directly connected EPS.

4.5. END-OF-LIFE PHASE

For disposal / recycling, the default entries of the EcoReport tool are assumed for all the product cases (Table 4-37). The printed circuit board is considered being easy to disassemble[46].

Table 4-37 – Disposal & recycling phase entries in 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 %	4	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	45	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	4	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)	4	9%	4
236	Plastics: Thermal Recycling (please edit% only)	37	90%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	7	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	24		fixed

4.6. CONCLUSIONS

This task presented the diversity of existing products (EPS/BC) that can fall into lot 7 and also set up the input database for the environmental analysis to be conducted during the task 5. It also analysed the products in a system context and how the external factors can affect their environmental and energy efficiency. The system analysis shows that many of the EPS's technical specifications are determined by the end-appliance while battery characteristics (such as the battery chemistry) set requirements to the battery charger technology.

46 Tested at Fraunhofer IZM labs, Berlin, Germany.

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5. DEFINITION OF BASE-CASES

This document presents Task 5 of the lot 7 EuP preparatory study on Battery Chargers (BC) and External power supplies (EPS). The task 5 comprises of an assessment of average EU product(s), the so called "base-cases".

A base-case is "a conscious abstraction of reality". The description of the base-case(s) is the synthesis of the results of Tasks 1 to 4. Most of the environmental and life cycle cost analysis are built on these base-cases throughout the rest of the study and it serves as the point-of-reference for Task 6 (technical analysis of BAT), Task 7(improvement potential), and Task 8 (impact analysis).

According to the MEUUP methodology, the scope of a preparatory study should be covered by one or two base-cases in Task 5. However, EPS and BC of varied characteristics exist which is derived from the fact they fulfil varied power requirements for a wide diversity of end-applications. Therefore, a larger number of base-cases will be required to represent the existing market segment in a comprehensive manner. Detailed analysis of a large number of base-cases will also allow us a more realistic assessment of improvement potentials in the subsequent tasks.

Therefore, most of the product-cases proposed in Task 4 were retained as base-cases. In total 21 external power supplies and battery chargers, covering the most important fields of application, served as basic data (see Task 4).The assessment of environmental impacts and life cycle costs (LCC) is hence based on the following base-cases:

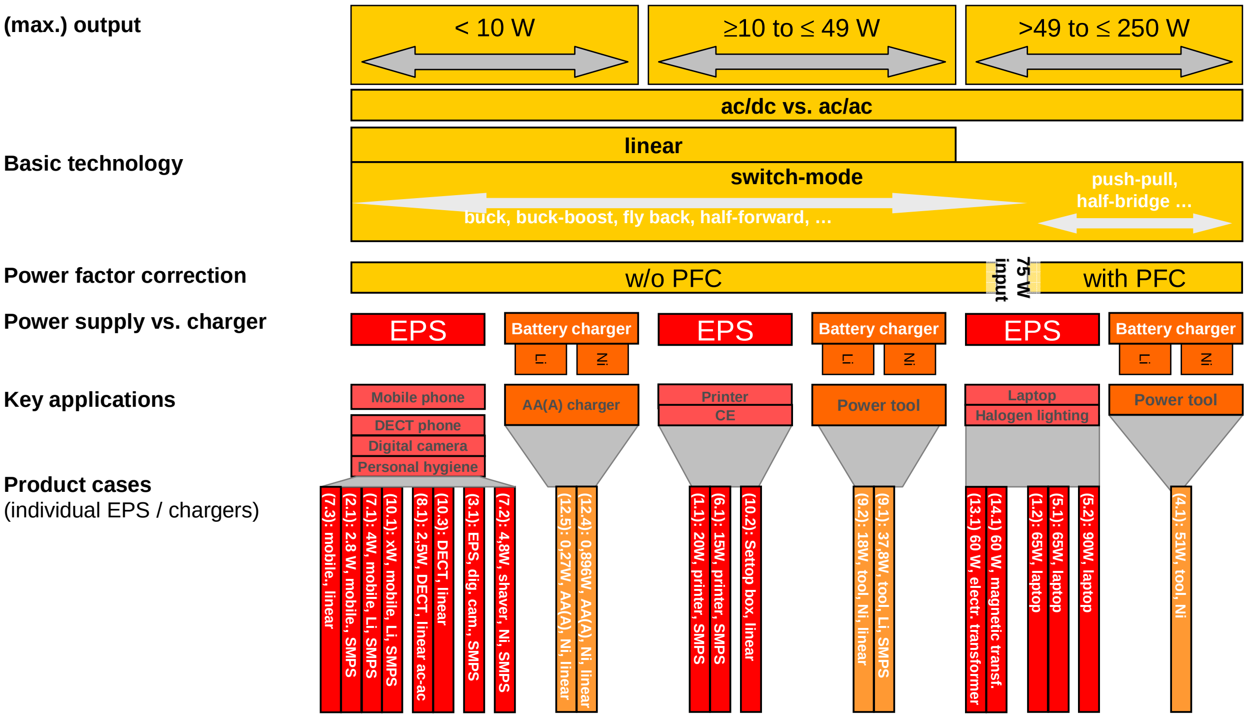
- Low wattage range (<10W)
    - Application (dominating market segment): mobile phone
    - Exemplary applications in other market segments:
        - digital camera,
        - shaver (as representative for personal care appliances),
        - cordless phone (being an example also for a market segment, where ac-ac power supplies are dominating)
    - Application: set-top box (as representative for home / office internet infrastructure and consumer electronics)
    - Standard battery charger (for AA/AAA batteries)
- Medium wattage range (10 – 49 W)
    - Application: power tool
    - Application: inkjet printer
- High wattage range (> 49 W)
    - Transformer for halogen lighting
        - Magnetic

- Electronic

▪ Application: laptop

- Without power factor correction (< 75 W input)
- With power factor correction (> 75 W input)

Figure 5-1 – Base-cases correlated to key applications and real product cases



After the analysis of the abovementioned base-cases, the results are aggregated in order to arrive at the total impacts of the Lot 7 products.

The base-cases are assessed with the EcoReport tool of MEEUP methodology (Tool for EcoReport Calculations, version 5[1]). The inputs data and results are thus presented in the EcoReport format. Main inputs to the analysis come from Task 2 and 4. Task 4 provides input data for the base-cases, namely, Bill of Materials (BOM), packaging and packaged volume, energy consumption during the use phase and considerations regarding the end-of-life of materials. EU sales and stock figures, as well as data on product prices, energy rates and interest-inflation rates were established in Task 2. These will serve to assess the Life Cycle Cost.

On the basis of Task 1, 3, and 4 it can be deduced that the differentiation between Standard and Real-Life base-cases, as proposed in the MEEuP, is not very distinct for this lot because no standard exist on the basis of which a "standard base-case" can be formulated. Even the only existing and most commonly adopted test scheme, the ENERGY STAR (see sub-task 1.2) does

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[1] It can be download at http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm

not define standard load profiles and use patterns. Hence, the base-case analysis for the lot 7 will be based on real life base cases.

The Task 5 document is structured as follows:

- Section 5.0 outlines the assumptions and inputs common to all base-cases.
- Sections 5.1 – 5.12 will present the individual base-case analyses: Specific inputs for the environmental impact assessment are given in sub-section 5.x.1; the environmental impact assessment in sub-section 5.x.2; the life cycle costs in 5.x.3, and the EU Totals in 5.x.4.
- Section 5.13 summarises the base-cases and presents estimates of the total impact of the lot 7 products. Total impact of the product system (as identified in Task 4) are also discussed.

Note:

It should be noted that due to the detailed split up of the whole lot 7 product category into the 12 base-cases, EIA results frequently show “0” for certain impact categories, even for the EU-25 totals per base-case. This is caused by the unit / scale prescribed in the EcoReport template (which cannot be changed) and rounding off the decimals. Consequently, regarding the impacts, “0” has to be read rather as “0 - 0.5”, not as zero impact.

5.0. ASSUMPTIONS AND COMMON INPUTS FOR BASE-CASES

The common assumptions and inputs for all base-cases are presented in the following sub-sections.

5.0.1 PRODUCT-SPECIFIC INPUTS

- BOM

  Regarding specific EcoReport entries for components and materials, 1/2 layer version of FR4 substrates is used as the printed wired board substrate for the EPS/BC. For the desktop type EPS/BC, the mains cable is not included in the BOM. (See section 4.1.1.)

- Manufacturing

  For average primary scrap production during sheet metal manufacturing, the default value of 25% proposed in the EcoReport for primary scrap is assumed for all the products.

- Distribution

  The average volume of the packaged product was taken, as defined in Task 4 (section 4.2.1). The weight of the (packaged) product is clearly below the threshold of 15 kg of the EcoReport tool (section 4.2.1). Thus, the question "Is it an ICT or Consumer Electronics product <15 kg?" is answered 'YES' for external power supplies and battery chargers although they are not an ICT or CE product as such. Upon request René Kemna, developer of the EcoReport tool, gave a clarification as follows: "The products heavier than 15 kg are intended to distinguish CRT TV's, where there is production of the heaviest component (glass) in the EU, from other electronics, which are usually outside the EU either as a product or main components."[2] As external power supplies and battery chargers are usually manufactured in East Asia the long distribution routes have to be taken into account by ticking 'YES', which leads to calculating a distribution route from production outside the EU.

- Use phase

  The energy consumption in the case of EPS/BC is the energy lost during the power conversion process and not the energy supplied to the end application. Hence, the energy consumption values utilised in the environmental impact and costs calculations are actually the losses which occur in these products.[3]

  See section 4.3.1.1 for pre-calculations and settings which were necessary for the calculation of use phase electricity consumption, as the entries in the EcoReport do not represent the energy input to the EPS/BC and it does not foresee entries for the different load modes. Section 4.3.1.3 and 4.3.1.5 present assumed average energy efficiencies and no-load losses.

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2 René Kemna, e-mail to Karsten Schischke, Fraunhofer IZM, Sept. 11, 2006
3 Energy consumption = power input-power output

As was discussed in Task 3, external power supplies and battery chargers, once broken, are usually replaced and not repaired. Consequently, for “Maintenance, Repairs, Service” the travelled distance is 0 km.

The EcoReport tool calculates a fixed 1% of components as spare parts. As this does not correspond with practice for EPS and battery chargers, the resulting impacts will not be taken into account for the interpretation of the results.

- Disposal & recycling

  For disposal and recycling the default entries of the EcoReport tool are assumed. The printed circuit board is considered being easy to disassemble. (See section 4.5.1.)

5.0.2 ENVIRONMENTAL IMPACT ASSESSMENT

Base-case environmental impacts assessment (EIA) is carried out for products manufactured and sold in 2005.

5.0.3 LIFE CYCLE COSTS

Inputs for Life Cycle Costs (LCC) are derived from previous tasks. Annex 2 summarised the LCC related parameters per base-case. The base-case LCC are assessed for products manufactured and sold in 2005.

5.0.4 EU TOTALS

The reference year for the EU totals is 2005 as for environmental impacts. ‘EU’ is synonymous to ‘EU-25’.

The annual sales and EU stock data were estimated in Task 2 (market analysis) and product life in Task 3.[4] The relevant cost data for external power supplies are the product price (which refers to EPS sold as accessory for an end-application and not as a separately sold replacement part which is priced many times higher than the manufacturing costs) and the electricity rate (EU average). For standard battery chargers (for AA/AAA batteries) the batteries are considered as additional consumables.

The “overall improvement ratio stock vs. new, use phase” is estimated with 10% (equals a ratio of 1.1), taking into account the market trend to replace linear EPS by switched-mode ones and the improvements achieved in switch-mode technology.

[4] see Annex 2 for summary of market and economic input parameters per base-case

5.1. 'MOBILE PHONE EPS' BASE-CASE

5.1.1 PRODUCT-SPECIFIC INPUTS

As outlined in the Market Analysis (Task 2), mobile phones represent the most important market segment in low power range i.e. below 10 W. The base-case on mobile phone EPS is based on four products from different manufacturers: three switch-mode and one linear mode EPS. In order to arrive at the base-case, data is averaged as follows: The SMPS each are calculated with a share of 26.7%, which corresponds in total to 80% switched-mode technology for the mobile phone segment, and 20% for the linear EPS. The resulting average BOM was already presented in section 4.1.2 (task 4).

The electricity consumption in the use phase was estimated in section 4.3.2. It was calculated with a rated output power of 4 W, an average efficiency of 66% and a load profile as defined in Task 3, consumer behaviour.

5.1.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

Table 5-1 shows the results of the environmental impact assessment of 'Mobile phone EPS' base-case[5]. The use phase impacts are calculated with an average product lifetime of 3 year.

5 More detailed results for this base-case are presented in Table 5A1- 1 in the Annexes.

Table 5-1 – EIA per product for 'Mobile phone EPS' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: EPS for mobile phones						Summary 4 Mobile Pl		KSchi		
	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			28			25	3	28	0
2	TecPlastics	g			15			13	1	15	0
3	Ferro	g			1			0	1	1	0
4	Non-ferro	g			11			1	11	11	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			32			16	16	32	0
7	Misc.	g			14			1	13	14	0
	Total weight	g			101			56	45	101	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	20	6	26	52	60	4	4	0	138
9	of which, electricity (in primary MJ)	MJ	4	1	6	0	60	0	2	-2	63
10	Water (process)	ltr	4	0	4	0	4	0	2	-2	7
11	Water (cooling)	ltr	7	2	8	0	159	0	0	0	167
12	Waste, non-haz./ landfill	g	194	9	203	52	71	6	6	1	327
13	Waste, hazardous/ incinerated	g	7	0	7	1	1	55	2	53	62
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1	0	1	5	3	0	0	0	9
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	11	2	13	12	15	1	2	-1	39
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	0	0	0	0	1
19	Heavy Metals	mg Ni eq.	2	0	2	3	1	1	0	1	6
	PAHs	mg Ni eq.	6	0	6	3	0	0	0	0	8
20	Particulate Matter (PM, dust)	g	1	1	2	1	0	5	0	5	8
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	3	0	3	0	0	0	1	-1	3
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The total energy consumption in the use phase is split up as follows:

42 % On-mode efficiency losses

58 % Off-mode losses

Based on the assessment results, focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency and reducing no-load losses**
2. Reducing weight / size of coils, transformers
3. Reducing PWB size
4. Reducing weight of copper and PVC in cable
5. Reducing weight / size / number of diodes
6. Reducing weight / size of big capacitors

However, the significance of weight / size of coils and transformers is mainly based on the 20% share for the linear EPS. Regarding the major market segment of switched-mode technology, this aspect is of much smaller relevancy.

The relevancy of the printed circuit board is based on the results in several life cycle stages: In materials extraction & production, manufacturing, and disposal / recycling each the printed circuit boards contribute to several environmental categories by more than 5%.

As mentioned before, there is limited data on use patterns regarding the aspect whether the user disconnects the EPS from the grid once the battery is fully loaded or not. The assessment given here is based on 10 h/d no-load, extremes would be 0 h/d and 23 h/d (the latter taking into account still 1 h/d of charging). For the extremes GER would change by -34 MJ and +79 MJ, which is significant but does not change the priority for the use phase impacts in comparison to other aspects.

5.1.3 Base-case Life Cycle Costs

According to the power range a product price of 3.50 Euro is assumed. However, in reality economy of scale play a significant role for the very large market of mobile phone EPS, and lead to much lower prices compared to other EPS in the same power range.

The Life Cycle Costs per product are 4 Euros (Table 5-2), quarter of which comes from the electricity i.e. power losses.[6]

Table 5-2 – LCC per product for EPS for mobile phones[7]

	Base Case: EPS for mobile phones *Item*	LCC new product
D	Product price	4 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	1 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	4 €

5.1.4 EU Totals

For the analysis of EU totals, the sales and market figures for mobile phone EPS base-case include also the market segment of portable audio / video devices.

6 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

7 The numbers are rounded off without decimals, which explains 4 plus 1 being equal to 4.

5.1.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of the new mobile phone EPS produced in 2005 over their lifetime are listed in the Table 5-3 below.

Table 5-3 – EU total impact of new EPS for mobile phones over their lifetime

Nr	**EU Impact of New Models sold 2005 over their lifetime:**						Date	Author			
0	Base Case: EPS for mobile phones						14.09.2006	KSchi			
	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	kt			8			7	1	8	0
2	TecPlastics	kt			4			4	0	4	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			3			0	3	3	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			9			4	4	9	0
7	Misc.	kt			4			0	3	4	0
	Total weight	kt			27			15	12	27	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	5	2	7	14	16	1	1	0	37
9	of which, electricity (in primary PJ)	PJ	1	0	2	0	16	0	1	-1	17
10	Water (process)	mln. m3	1	0	1	0	1	0	0	0	2
11	Water (cooling)	mln. m3	2	0	2	0	43	0	0	0	45
12	Waste, non-haz./ landfill	kt	52	2	55	14	19	2	1	0	88
13	Waste, hazardous/ incinerated	kt	2	0	2	0	0	15	1	14	17
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	1	1	0	0	0	2
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	3	1	3	3	4	0	0	0	11
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	1	0	0	0	0	2
	PAHs	ton Ni eq.	2	0	2	1	0	0	0	0	2
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	1	0	1	2
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	1	0	1	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

***=Note: mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9 g; ton(metric)= 10^9 g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

5.1.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of mobile phone EPS in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the mobile phone EPS stock is 27 000 tons, the total annual energy consumption in 2005 (GER) is 39 PJ.

Table 5-4 – EU total annual impact of stock of EPS for mobile phones (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***								Date	Author	
	Base Case: EPS for mobile phones								14.09.2006	KSchi	
	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	kt			8			7	1	8	0
2	TecPlastics	kt			4			4	0	4	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			3			0	3	3	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			9			4	4	9	0
7	Misc.	kt			4			0	3	4	0
	Total weight	kt			27			15	12	27	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	5	2	7	14	18	1	1	0	39
9	of which, electricity (in primary PJ)	PJ	1	0	2	0	18	0	1	-1	19
10	Water (process)	mln. m3	1	0	1	0	1	0	0	0	2
11	Water (cooling)	mln. m3	2	0	2	0	47	0	0	0	49
12	Waste, non-haz./ landfill	kt	52	2	55	14	21	2	1	0	90
13	Waste, hazardous/ incinerated	kt	2	0	2	0	0	15	1	14	17
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	1	1	0	0	0	2
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	3	1	3	3	5	0	0	0	11
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	1	0	0	0	0	2
	PAHs	ton Ni eq.	2	0	2	1	0	0	0	0	2
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	1	0	1	2
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	1	0	1	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Table 5-5 – Summary of EU total annual impact of mobile phones EPS stock

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: EPS for mobile phones

main life cycle indicators	value	unit
Total Energy (GER)	**39**	PJ
of which, electricity	1,8	TWh
Water (process)*	2	mln.m3
Waste, non-haz./ landfill*	90	kton
Waste, hazardous/ incinerated*	17	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**2**	mt CO2eq.
Acidifying agents (AP)	**11**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**2**	ton Ni eq.
PAHs	**2**	ton Ni eq.
Particulate Matter (PM, dust)	**2**	kt
Emissions (Water)		
Heavy Metals (HM)	1	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As presented in the Table 5-6 below, the annual consumer expenditure for the 2005 stock of mobile phone EPS are in the range of 1170 million Euros for EU-25, thereof 229 million Euros (20%) on electricity, i.e. power losses[8].

Table 5-6 – EU total annual consumer expenditure for mobile phone EPS

	Base Case: EPS for mobile phones *Item*	**total annual consumer expenditure in EU25**
D	Product price	942 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	229 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**1170** mln.€

8 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.2. 'DECT PHONE EPS' BASE-CASE

5.2.1 PRODUCT-SPECIFIC INPUTS

The base-case on DECT phone EPS is based on a blend of two types: an AC-AC power supply and an AC-DC power supply in linear technology. The average BOM for a DECT phone EPS was already presented in section 4.1.2. The electricity consumption in the use phase is calculated with the rated output power of 2.5 W, an average efficiency of 55% and the load profile as defined in task 3, consumer behaviour[9]. The use phase impacts are calculated with an average product lifetime of 5 years.

5.2.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The summarised results of the environmental impact analysis of the DECT phone EPS base-case are shown in Table 5-7.[10]

9 =((1/0.55)-1)*3*0.0025+((1/0.55)-1)*1*0.75*0.0025+((1/0.55)-1)*20*0.5*0.0025

10 See Table 5A1- 2 in Annexes for more detailed results for this base-case.

Table 5-7 – EIA per product for 'DECT phone EPS' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: DECT phone EPS							24.11.06	Kschi		
	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			14			13	1	14	0
2	TecPlastics	g			34			31	3	34	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			16			1	16	16	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			197			99	98	197	0
7	Misc.	g			38			2	36	38	0
	Total weight	g			300			145	155	300	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	86	27	114	53	648	11	17	-7	808
9	of which, electricity (in primary MJ)	MJ	8	2	9	0	647	0	11	-11	645
10	Water (process)	ltr	11	2	14	0	43	0	10	-10	47
11	Water (cooling)	ltr	14	8	22	0	1725	0	2	-2	1745
12	Waste, non-haz./ landfill	g	420	27	448	52	754	18	33	-15	1239
13	Waste, hazardous/ incinerated	g	7	1	8	1	15	142	13	129	153
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	5	2	7	5	28	1	1	0	39
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	37	10	47	12	167	2	9	-7	219
17	Volatile Organic Compounds (VOC)	g	0	1	1	0	0	0	0	0	1
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	1	0	4	0	0	0	5
19	Heavy Metals	mg Ni eq.	4	0	4	3	11	3	1	1	19
	PAHs	mg Ni eq.	39	1	39	3	2	0	1	-1	42
20	Particulate Matter (PM, dust)	g	7	3	10	1	4	13	0	13	28
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	16	0	16	0	4	1	7	-6	14
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency**
2. Reducing weight / size of coils, transformers
3. Reducing weight of copper and PVC in cable

5.2.3 BASE-CASE LIFE CYCLE COSTS

According to the power range a product price of 3,50 Euro is assumed. The Life Cycle Costs per product are 11 Euros (Table 5-2), 64% of which comes from the electricity i.e. power losses.[11]

11 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

Table 5-8 – LCC per product for EPS for DECT phones

	Base Case: DECT phone EPS *Item*	LCC new product
D	Product price	4 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	7 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**11** €

5.2.4 EU TOTALS

5.2.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of the new DECT phone EPS produced in 2005 over their lifetime are listed in the Table 5-9 below.

Table 5-9 – EU total impact of new EPS for DECT phones over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base Case: DECT phone EPS						24.11.06		Kschi		
	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	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**1**			1	0	**1**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**6**			3	3	**6**	**0**
7	Misc.	kt			**1**			0	1	**1**	**0**
	Total weight	kt			**9**			4	5	**9**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	**3**	**2**	**19**	0	1	**0**	**24**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**19**	0	0	**0**	**19**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	**1**	**0**	**52**	0	0	**0**	**52**
12	Waste, non-haz./ landfill	kt	13	1	**13**	**2**	**23**	1	1	**0**	**37**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	4	0	**4**	**5**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**5**	0	0	**0**	**7**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	PAHs	ton Ni eq.	1	0	**1**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.2.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of DECT phone EPS in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the DECT phone EPS stock is 9000 tons, the total annual energy consumption (GER) is 23 PJ.

Table 5-10 – EU total annual impact of stock of EPS for DECT phones (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base Case: DECT phone EPS						24.11.06		Kschi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			6			3	3	6	0
7	Misc.	kt			1			0	1	1	0
	Total weight	kt			9			4	5	9	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	3	2	18	0	1	0	23
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	18	0	0	0	18
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	1	0	47	0	0	0	48
12	Waste, non-haz./ landfill	kt	13	1	13	2	21	1	1	0	35
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	4	0	4	5
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	5	0	0	0	6
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

Table 5-11 – Summary of EU total annual impact of 'DECT phone EPS' stock

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: DECT phone EPS		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**23**	PJ
of which, electricity	1,7	TWh
Water (process)*	**1**	mln.m3
Waste, non-haz./ landfill*	**35**	kton
Waste, hazardous/ incinerated*	**5**	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**1**	mt CO2eq.
Acidifying agents (AP)	**6**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**1**	ton Ni eq.
PAHs	**1**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

As presented in the Table 5-12 below, the annual consumer expenditure for the 2005 stock of DECT phone EPS are in the range of 335 million Euros for EU-25, thereof 230 million Euros (69%) on electricity, i.e. power losses.

Table 5-12 – EU total annual consumer expenditure for DECT phone EPS

	Base Case: DECT phone EPS *Item*	**total annual consumer expenditure in EU25**
D	Product price	105 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	230 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**335** mln.€

5.3. 'DIGITAL CAMERA EPS' BASE-CASE

5.3.1 PRODUCT-SPECIFIC INPUTS

The base-case on digital camera EPS is based on one best selling product in switched-mode technology from a leading OEM, which was already presented in Task 4; for BOM[12], see section 4.1.2.

Typical digital camera EPS electricity consumption is calculated with a rated output power of 6.5 W, an average efficiency of 70% and a load profile as defined in task 3, consumer behaviour[13]. (See section 4.3.2)

5.3.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The assessment of environmental impacts is given in Table 5-13. The use phase impacts were calculated with an average product lifetime of 3 year.

12 For confidentiality reasons the BOM was presented with less detail than e.g. in the case of mobile phone EPS. However, this will not affect the analysis results as they were carried out using greater level of detail.

13 =((1/0.70)-1)*(0.05*0.25*0.0065+0.25*1*0.0065)

Table 5-13 – EIA results for the base-case 'EPS for digital camera'

Nr	Life cycle Impact per product:								Date	Author	
0	EPS for digital camera								02.11.2006	KSchi	
	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			26			23	3	26	0
2	TecPlastics	g			19			17	2	19	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			26			1	25	26	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			30			16	14	30	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			101			57	43	101	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	19	5	24	53	43	4	4	0	120
9	of which, electricity (in primary MJ)	MJ	3	1	5	0	43	0	2	-2	46
10	Water (process)	ltr	3	0	4	0	3	0	1	-1	5
11	Water (cooling)	ltr	7	2	9	0	114	0	0	0	123
12	Waste, non-haz./ landfill	g	554	9	563	52	55	6	5	1	672
13	Waste, hazardous/ incinerated	g	9	0	9	1	1	54	2	52	64
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1	0	1	5	2	0	0	0	8
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	14	2	16	12	11	1	1	-1	39
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	0	0	0	0	1
19	Heavy Metals	mg Ni eq.	2	0	2	3	1	1	0	1	7
	PAHs	mg Ni eq.	4	0	4	3	0	0	0	0	7
20	Particulate Matter (PM, dust)	g	1	0	2	1	0	5	0	5	7
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	4	0	4	0	0	0	1	-1	4
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The most significant difference compared to mobile phone EPS is the ratio of efficiency losses and no-load losses as digital cameras are charged less often than mobile phones: The total energy consumption in the use phase is split up as follows:

20 % On-mode efficiency losses

80 % Off-mode losses

5.3.3 BASE-CASE LIFE CYCLE COSTS

For the Life Cycle Cost calculation, a product price of 6.50 Euro is taken, according to the power range. The market figures include also the segment of camcorders.

The Life Cycle Costs per product are 7 Euros (Table 5-14), approximately one tenth of which comes from the electricity i.e. power losses.[14]

Table 5-14 – LCC per product for EPS for digital cameras[15]

	EPS for digital camera *Item*	LCC new product
D	Product price	7 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	1 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	7 €

5.3.4 EU TOTALS

5.3.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total impact of EPS for digital cameras (including video cameras) produced in 2005 over their lifetime is listed in the table below.

Total weight of the EPS is 4 000 tons, the total energy consumption (GER) is 4 PJ.

---

14 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

15 The numbers are rounded off without decimals, which explains 7 plus 1 being equal to 7.

Table 5-15 – EU total impact of new EPS for digital cameras over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	EPS for digital camera						02.11.2006		KSchi		
	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	kt			1			1	0	1	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			1			1	0	1	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			4			2	2	4	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	2	2	0	0	0	4
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	2	0	0	0	2
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	4	0	0	0	4
12	Waste, non-haz./ landfill	kt	20	0	20	2	2	0	0	0	24
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	2	0	2	2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	0	0	0	0	1
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

5.3.4.2 ANNUAL IMPACT OF THE STOCK

For the 2005 stock of digital camera EPS the total annual environmental impacts are listed in the tables below.

Table 5-16 – EU total annual impact of stock of digital camera EPS (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	EPS for digital camera						02.11.2006		KSchi		
	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	kt			1			1	0	1	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			1			1	0	1	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			4			2	2	4	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	2	2	0	0	0	4
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	2	0	0	0	2
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	5	0	0	0	5
12	Waste, non-haz./ landfill	kt	20	0	20	2	2	0	0	0	24
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	2	0	2	2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	0	0	0	0	1
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

Table 5-17 – Summary EU total annual impact of digital cameras EPS stock

Table . Summary Environmental Impacts EU-Stock 2005, EPS for digital camera

main life cycle indicators	value	unit
Total Energy (GER)	**5**	PJ
of which, electricity	0,2	TWh
Water (process)*	0	mln.m3
Waste, non-haz./ landfill*	24	kton
Waste, hazardous/ incinerated*	2	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**1**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As listed in Table 5-18, the annual consumer expenditure for the 2005 stock of digital cameras (including video cameras) is in the range of 256 million Euro for EU-25, thereof 22 million Euro on electricity (power losses)[16].

Table 5-18 – EU total annual consumer expenditure for digital camera EPS

	EPS for digital camera *Item*	total annual consumer expenditure in EU25	
D	Product price	234	mln.€
E	Installation/ acquisition costs (if ar	0	mln.€
F	Fuel (gas, oil, wood)	0	mln.€
F	Electricity	22	mln.€
G	Water	0	mln.€
H	Aux. 1: None	0	mln.€
I	Aux. 2 :None	0	mln.€
J	Aux. 3: None	0	mln.€
K	Repair & maintenance costs	0	mln.€
	Total	**256**	mln.€

16 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.4. ‘SET-TOP BOX / MODEM EPS’ BASE-CASE

5.4.1 PRODUCT-SPECIFIC INPUTS

The base-case on set-top box / modem EPS is based on one best selling linear mode product. The BOM was already presented in section 4.1.2. The use phase electricity consumption is calculated with an output power of 8.45 W, an average efficiency of 70% of this power segment[17] and a load profile as defined in task 3, consumer behaviour[18]. (See section 4.3.2)

5.4.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The use phase impacts are calculated with an average 3 year product lifetime[19]. In almost all impact categories the use phase, meaning efficiency losses, is clearly dominating (Table 5-19). Among the materials and extraction life cycle phase the transformer is dominating the overall environmental impacts.

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17 Which is assumed for this power segment, but rather overestimates the efficiency of the – mainly – linear designs for this kind of application

18 =((1/0.70)-1)*(21*0.5*0.00845+3*1*0.00845)

19 The average product lifetime of 3 year corresponds rather with modems / computer peripherals (majority with EPS) than with TV set-top boxes (mostly have an internal power supply)

Table 5-19 – EIA per product for 'set-top box / modem EPS' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base case: Settop box EPS							7.11.06	Kschi		
	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			23			21	2	23	0
2	TecPlastics	g			52			47	5	52	0
3	Ferro	g			1			0	1	1	0
4	Non-ferro	g			15			1	15	15	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			285			141	144	285	0
7	Misc.	g			19			1	18	19	0
	Total weight	g			396			210	185	396	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	119	40	160	53	564	16	26	-10	766
9	of which, electricity (in primary MJ)	MJ	3	3	5	0	562	0	17	-17	551
10	Water (process)	ltr	12	3	15	0	38	0	15	-15	38
11	Water (cooling)	ltr	23	11	34	0	1499	0	3	-3	1530
12	Waste, non-haz./ landfill	g	325	41	366	52	655	24	49	-24	1049
13	Waste, hazardous/ incinerated	g	10	1	11	1	13	212	19	193	219
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	7	3	9	5	25	1	2	-1	38
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	45	15	60	12	145	2	13	-11	207
17	Volatile Organic Compounds (VOC)	g	0	1	1	0	0	0	0	0	1
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	1	0	4	0	0	0	5
19	Heavy Metals	mg Ni eq.	3	0	3	3	10	4	2	2	18
	PAHs	mg Ni eq.	58	1	59	3	2	0	2	-2	61
20	Particulate Matter (PM, dust)	g	11	4	15	1	3	20	1	19	38
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	22	0	22	0	4	1	10	-8	17
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

5.4.3 BASE-CASE LIFE CYCLE COSTS

According to the power range a consumer price of 7 Euros is assumed. The Life Cycle Costs per product are 13 Euros (Table 5-20), approximately half of which come from the electricity i.e. power losses.

Table 5-20 – LCC per product for EPS for set-top box / modem

	Base case: Settop box EPS *Item*	LCC new product
D	Product price	7 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	7 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**13** €

5.4.4 EU TOTALS

5.4.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of EPS for set-top box / modem produced in 2005 is listed in the table below. Total weight of the 2005 produced set-top box / modem EPS is 9000 tons, the total energy consumption (GER) is 18 PJ.

Table 5-21 – EU total impact of new set-top box/modem EPS over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base case: Settop box EPS							7.11.06	Kschi		

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	kt			1			0	0	1	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			7			3	3	7	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			9			5	4	9	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	4	1	13	0	1	0	18
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	13	0	0	0	13
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	1	0	1	0	34	0	0	0	35
12	Waste, non-haz./ landfill	kt	7	1	8	1	15	1	1	-1	24
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	5	0	4	5
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	3	0	0	0	5
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	1	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.4.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of set-top box / modem EPS in 2005 (produced, in use, discarded) the total environmental impacts are listed in the tables below. Total weight of the stock is 9000 tons, the total annual energy consumption (GER) is 19 PJ.

Table 5-22 – EU total annual impact of stock of set-top box/modem EPS (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base case: Settop box EPS							7.11.06	Kschi		
	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	kt			**1**			0	0	**1**	**0**
2	TecPlastics	kt			**1**			1	0	**1**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**7**			3	3	**7**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**9**			5	4	**9**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	**4**	**1**	**14**	0	1	**0**	**19**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**14**	0	0	**0**	**14**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	1	0	**1**	**0**	**38**	0	0	**0**	**38**
12	Waste, non-haz./ landfill	kt	7	1	**8**	**1**	**17**	1	1	**-1**	**26**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	5	0	**4**	**5**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**4**	0	0	**0**	**5**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	1	0	**1**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**1**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

Table 5-23 – Summary of EU total annual impact of set-top box/modem EPS stock

Table . Summary Environmental Impacts EU-Stock 2005, Base case: Settop box EPS

main life cycle indicators	value	unit
Total Energy (GER)	**19**	PJ
of which, electricity	1,3	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	26	kton
Waste, hazardous/ incinerated*	5	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**1**	mt CO2eq.
Acidifying agents (AP)	**5**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**1**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As presented in Table 5-24 below, the annual consumer expenditure for the 2005 stock of EPRS for set-top box / modem (incl. Wi-Fi access points etc.) are in the range of 332 million Euros for EU-25, thereof 183 million Euros on electricity, i.e. power losses[20].

Table 5-24 – EU total annual consumer expenditure for the stock of set-top box/modem EPS

	Base case: Settop box EPS *Item*	total annual consumer expenditure in EU25	
D	Product price	149	mln.€
E	Installation/ acquisition costs (if an'	0	mln.€
F	Fuel (gas, oil, wood)	0	mln.€
F	Electricity	183	mln.€
G	Water	0	mln.€
H	Aux. 1: None	0	mln.€
I	Aux. 2 :None	0	mln.€
J	Aux. 3: None	0	mln.€
K	Repair & maintenance costs	0	mln.€
	Total	**332**	mln.€

20 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.5. ‘PERSONAL CARE APPLIANCE EPS’ BASE-CASE

5.5.1 PRODUCT-SPECIFIC INPUTS

The base-case on power supplies for personal care appliance is based on a best selling external power supply unit for a shaver of a switched-mode design (see Task 4). The BOM was presented in section 4.1.2.

The electricity consumption in use phase is calculated with 4.8 W output power, an average efficiency of 63% for this power segment[21] and a load profile as defined in task 3, consumer behaviour[22]. (See section 4.3.2)

5.5.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impact assessment is given in Table 5-25 below. The use phase impacts were calculated with an average 4 year product lifetime.

The most significant difference compared to mobile phone EPS is the fact that a shaver, and other similar appliances which are in (nearly) daily use, usually always stays connected to the charging base for the convenience of the user. Hence, the EPS is operating for most of the time under low load (mainly trickle charging of the shaver battery) and the no-load state is usually irrelevant.

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21 The exemplary power supply taken for BOM calculations here actually has an average efficiency of approx. 65.5%

22 =((1/0.63)-1)*(22*0.25*0.0048+2*1*0.0048)

Table 5-25 – EIA per product for 'EPS for personal care appliance' base-case

Nr	Life cycle Impact per product:	Date	Author
0	Base case: Personal Care EPS	3.11.06	Kschi

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			**23**			21	2	**23**	**0**
2	TecPlastics	g			**26**			23	3	**26**	**0**
3	Ferro	g			**2**			0	1	**2**	**0**
4	Non-ferro	g			**19**			1	18	**19**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**19**			11	8	**19**	**0**
7	Misc.	g			**11**			1	10	**11**	**0**
	Total weight	g			**100**			57	43	**100**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	16	4	**21**	**53**	**324**	4	3	**1**	**398**
9	of which, electricity (in primary MJ)	MJ	5	1	**6**	**0**	**324**	0	1	**-1**	**329**
10	Water (process)	ltr	5	0	**5**	**0**	**22**	0	1	**-1**	**25**
11	Water (cooling)	ltr	6	1	**7**	**0**	**864**	0	0	**0**	**871**
12	Waste, non-haz./ landfill	g	311	8	**319**	**52**	**379**	6	3	**3**	**753**
13	Waste, hazardous/ incinerated	g	8	0	**8**	**1**	**8**	53	1	**51**	**68**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1	0	**1**	**5**	**14**	0	0	**0**	**20**
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	11	1	**13**	**12**	**84**	1	1	**0**	**108**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	**0**	**0**	**2**	0	0	**0**	**3**
19	Heavy Metals	mg Ni eq.	2	0	**2**	**3**	**6**	1	0	**1**	**12**
	PAHs	mg Ni eq.	3	0	**3**	**3**	**1**	0	0	**0**	**6**
20	Particulate Matter (PM, dust)	g	1	0	**1**	**1**	**2**	5	0	**5**	**9**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	3	0	**3**	**0**	**2**	0	1	**0**	**4**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

5.5.3 BASE-CASE LIFE CYCLE COSTS

According to the power range a product price of 3.50 Euro is assumed. As can be seen from Table 5-26, the Life Cycle Costs per product are approximately 7 Euros, half of which comes from the electricity i.e. power losses.

Table 5-26 – LCC per product for EPS for personal care appliance

	Base case: Personal Care EPS *Item*	LCC new product	
D	Product price	4	€
E	Installation/ acquisition costs (if any)	0	€
F	Fuel (gas, oil, wood)	0	€
F	Electricity	4	€
G	Water	0	€
H	Aux. 1: None	0	€
I	Aux. 2 :None	0	€
J	Aux. 3: None	0	€
K	Repair & maintenance costs	0	€
	Total	7	€

5.5.4 EU TOTALS

5.5.4.1 TOTAL LIFE CYCLE IMPACTS

The total impact of EPS for personal care appliances produced in 2005 over their lifetime is listed in the table below. Total weight of the EPS for personal care appliances is 1 000 tons, the total energy consumption (GER) is 4 PJ.

Table 5-27 – EU total impact of new EPS for personal care appliances over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base case: Personal Care EPS							3.11.06	Kschi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			1			1	0	1	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	1	3	0	0	0	4
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	3	0	0	0	3
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	9	0	0	0	9
12	Waste, non-haz./ landfill	kt	3	0	3	1	4	0	0	0	8
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	1	0	1	1
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	1	0	0	0	1
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.5.4.2 Annual impact of the stock

For the stock of personal care appliance EPS in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of this EPS stock is 1000 tons, the total annual energy consumption (GER) is 4 PJ.

Table 5-28 – EU total annual impact of the stock of EPS for personal care appliances (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base case: Personal Care EPS						3.11.06		Kschi		
	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	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**1**			1	0	**1**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**1**	**4**	0	0	**0**	**4**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**4**	0	0	**0**	**4**
10	Water (process)	mln. m3	0	0	**0**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**10**	0	0	**0**	**10**
12	Waste, non-haz./ landfill	kt	3	0	**3**	**1**	**4**	0	0	**0**	**8**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Table 5-29 – Summary of EU total annual impacts of the stock of EPS for personal care appliances

Table . Summary Environmental Impacts EU-Stock 2005, Base case: Personal Care EPS		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**4**	PJ
of which, electricity	0,3	TWh
Water (process)*	0	mln.m3
Waste, non-haz./ landfill*	8	kton
Waste, hazardous/ incinerated*	1	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**1**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4
*=caution: low accuracy for production phase		

As presented in the Table 5-30 below, the annual consumer expenditure for the 2005 stock of personal care appliance EPS are in the range of 81 million Euros for EU-25, thereof 46 million Euros on electricity, i.e. power losses[23].

Table 5-30 – EU total annual consumer expenditure for the stock of personal care appliance EPS

	Base case: Personal Care EPS *Item*	**total annual consumer expenditure in EU25**
D	Product price	35 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	46 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**81** mln.€

23 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.6. 'STANDARD (AA/AAA) BATTERY CHARGER' BASE-CASE

5.6.1 PRODUCT-SPECIFIC INPUTS

The BOM (see section 4.1.2) of the base-case on standard battery chargers is based on two best-selling standard overnight chargers with linear power transformation.

Use phase entries for standard battery charger were already defined in Task 4 (section 4.3.2). Energy use during the charge cycle was estimated at 2.5 kWh / year. Furthermore, the charger remains assumed 2.75 hours per day in no-load mode with a loss of 2.3 W in average. Batteries were taken into account as consumables.

5.6.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

Table 5-31 shows the results of the standard battery charger base-case.[24] The impact of the use phase was calculated with an average 5 year product lifetime.

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24 See Table 5A1- 3 for more detailed results for this base-case.

Table 5-31 – EIA for 'Standard Battery Charger' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: Standard Battery Charger							12.11.2006	KSchi		
	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			**3**			3	0	**3**	**0**
2	TecPlastics	g			**58**			52	6	**58**	**0**
3	Ferro	g			**89**			4	84	**89**	**0**
4	Non-ferro	g			**29**			1	27	**29**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**144**			74	70	**144**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**323**			135	188	**323**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	71	22	**93**	**53**	**253**	10	14	**-4**	**395**
9	of which, electricity (in primary MJ)	MJ	7	3	**10**	**0**	**253**	0	8	**-8**	**254**
10	Water (process)	ltr	16	2	**18**	**0**	**17**	0	7	**-7**	**27**
11	Water (cooling)	ltr	17	6	23	0	673	0	2	-2	695
12	Waste, non-haz./ landfill	g	780	31	**811**	**52**	**301**	20	24	**-4**	**1160**
13	Waste, hazardous/ incinerated	g	18	1	**18**	**1**	**6**	126	9	**116**	**142**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	4	1	**6**	**5**	**11**	1	1	**0**	**21**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	38	8	**46**	**12**	**65**	1	6	**-5**	**119**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**0**	0	0	**0**	**1**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	**1**	**0**	**2**	0	0	**0**	**3**
19	Heavy Metals	mg Ni eq.	17	1	**18**	**3**	**5**	3	1	**2**	**26**
	PAHs	mg Ni eq.	26	0	**26**	**3**	**1**	0	1	**-1**	**28**
20	Particulate Matter (PM, dust)	g	6	2	**8**	**1**	**1**	12	0	**12**	**22**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	20	0	**20**	**0**	**2**	1	5	**-4**	**18**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The use phase energy consumption is split up as follows:

52 % Charging efficiency losses

48 % Off-mode losses

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing charging efficiency and reducing no-load losses**
2. Reducing weight / size of coils / transformer
3. Reducing PWB size
4. Reducing weight / size of metal parts
5. Reducing weight of copper cable

The batteries, as consumables for BC, are not included in the environmental assessment because the EcoReport database does not have batteries as input. Further research and literature research did not result in required input data for calculating environmental impacts of batteries. As a very rough approximation, if we simulate the EcoReport analysis for four standard AA batteries (which the charger is assumed to consume during its lifetime) and assuming them to be "big caps & coils" in EcoReport as their construction is in some way comparable with electrolytic capacitors, significantly additional environmental impacts can be observed (see Table 5-32).

Table 5-32 – Simulated EIA of 4 AA batteries (assuming them big caps & coils)

Nr	Life cycle Impact per product:	Date	Author
0	4 Batteries over 5 years lifetime of a standard battery charger	0	KSchi

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			**0**			0	0	**0**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**0**			0	0	**0**	**0**
4	Non-ferro	g			**0**			0	0	**0**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**111**			55	55	**111**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**111**			55	55	**111**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	42	14	**57**	**0**	**1**	4	9	**-5**	**53**
9	of which, electricity (in primary MJ)	MJ	0	0	**0**	**0**	**0**	0	6	**-6**	**-6**
10	Water (process)	ltr	4	1	**5**	**0**	**0**	0	6	**-6**	**-1**
11	Water (cooling)	ltr	6	4	**10**	**0**	**0**	0	1	**-1**	**9**
12	Waste, non-haz./ landfill	g	67	12	**78**	**0**	**1**	7	19	**-12**	**67**
13	Waste, hazardous/ incinerated	g	2	0	**3**	**0**	**0**	55	7	**48**	**51**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	2	1	**3**	**0**	**0**	0	1	**0**	**3**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	16	5	**21**	**0**	**0**	1	5	**-4**	**17**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	mg Ni eq.	1	0	**1**	**0**	**0**	1	1	**0**	**1**
	PAHs	mg Ni eq.	23	0	**23**	**0**	**0**	0	1	**-1**	**23**
20	Particulate Matter (PM, dust)	g	4	2	**6**	**0**	**0**	5	0	**5**	**11**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	8	0	**8**	**0**	**0**	0	4	**-3**	**5**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

5.6.3 BASE-CASE LIFE CYCLE COSTS

For the calculation of Life Cycle Costs, a product price of 15 Euros is used (task 2). The LCC costs include the price of 4 batteries (Aux. 1 in the table below), which the charger is assumed to consume during its lifetime, as discussed in section 4.3.2 (task 4).

The product price is makes up approximately half of the Life Cycle Costs; contribution of batteries is also significant (Table 5-33).[25]

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25 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

Table 5-33 – LCC per product for Standard battery charger base-case

	Base Case: Standard Battery Charger *Item*	LCC new product
D	Product price	15 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	3 €
G	Water	0 €
H	Aux. 1: None	10 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	28 €

5.6.4 EU TOTALS

5.6.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of the new standard battery chargers produced in 2005 over their lifetime are listed in the Table 5-34 below.

Table 5-34 – EU total impact of new EPS for standard battery chargers over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:	Date	Author
0	Base Case: Standard Battery Charger	12.11.2006	KSchi

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	kt			0			0	0	0	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			2			0	2	2	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			3			1	1	3	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			6			3	4	6	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	2	1	5	0	0	0	8
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	5	0	0	0	5
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	13	0	0	0	14
12	Waste, non-haz./ landfill	kt	16	1	16	1	6	0	0	0	23
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	3	0	2	3
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	1	0	0	0	2
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

5.6.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of standard battery chargers in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the standard battery chargers stock is 6000 tons, the total annual energy consumption (GER) is 8 PJ.

Table 5-35 – EU total annual impact of the stock of standard battery chargers (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base Case: Standard Battery Charger						12.11.2006		KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			2			0	2	2	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			3			1	1	3	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			6			3	4	6	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	2	1	6	0	0	0	8
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	6	0	0	0	6
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	15	0	0	0	15
12	Waste, non-haz./ landfill	kt	16	1	16	1	7	0	0	0	24
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	3	0	2	3
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	1	0	0	0	3
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Table 5-36 – Summary of EU total annual impact of the standard battery charger stock

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Standard Battery Charger

main life cycle indicators	value	unit
Total Energy (GER)	**8**	PJ
of which, electricity	0,5	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	24	kton
Waste, hazardous/ incinerated*	3	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**3**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**1**	ton Ni eq.
PAHs	**1**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As presented in the Table 5-37 below, the annual consumer expenditure for the 2005 stock of standard battery chargers are in the range of 612 million Euros for EU-25[26]. The cost of batteries, which was taken into account for this base-case (Aux. 1 in the table below), makes up 40% of the total expenditure.

Table 5-37 – EU total annual consumer expenditure for standard battery chargers

	Base Case: Standard Battery Charger *Item*	**total annual consumer expenditure in EU25**
D	Product price	300 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	72 mln.€
G	Water	0 mln.€
H	Aux. 1: None	240 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**612** mln.€

26 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.7. 'POWER TOOL CHARGER' BASE-CASE

5.7.1 PRODUCT-SPECIFIC INPUTS

The base-case on power tool chargers is based on three products:18 W output (linear), 37.8 W (switched-mode) and 51 W (switched-mode)[27]. These three chargers were averaged arithmetically for the base-case BOM (see section 4.1.2), as they represent the usual power range of power tools adequately.

As the life times and use patterns for professional and DIY tools are very different, the use phase environmental impacts are calculated as a weighed average of professional and DIY tools, which were presented in section 4.3.2, based on task 3 (consumer behaviour).

5.7.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The following table shows the results of the 'charger for power tool' base-case. The impacts of the use phase were calculated with an average product lifetime of 5.5 years.

27 This charger does not fall in the power range of 10-49 W but is considered here to allow for a base-case, which covers power tools in general

Table 5-38 – EIA for 'Charger for power tool' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: Power tool charger							02.10.2006	Kschi		
	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			199			179	20	199	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			3			0	2	3	0
4	Non-ferro	g			51			3	48	51	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			346			178	167	346	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			598			360	237	598	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	185	51	236	53	87	25	35	-9	367
9	of which, electricity (in primary MJ)	MJ	54	6	60	0	85	0	19	-19	126
10	Water (process)	ltr	37	4	41	0	6	0	18	-18	29
11	Water (cooling)	ltr	56	14	70	0	226	0	4	-4	293
12	Waste, non-haz./ landfill	g	990	62	1051	52	109	37	56	-20	1193
13	Waste, hazardous/ incinerated	g	56	1	58	1	3	346	22	325	386
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	10	3	13	5	4	2	2	0	21
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	92	18	111	12	23	4	15	-12	134
17	Volatile Organic Compounds (VOC)	g	0	1	1	0	0	0	0	0	1
18	Persistent Organic Pollutants (POP)	ng i-Teq	2	0	2	0	1	0	0	0	3
19	Heavy Metals	mg Ni eq.	14	0	14	3	2	7	2	4	23
	PAHs	mg Ni eq.	54	1	55	3	1	0	2	-2	56
20	Particulate Matter (PM, dust)	g	11	5	17	1	1	33	1	32	50
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	25	0	25	0	1	2	11	-9	17
22	Eutrophication	g PO4	1	0	1	0	0	0	0	0	1
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

5.7.3 BASE-CASE LIFE CYCLE COSTS

A product price of 19.50 Euros[28] was assumed for power tool charger base-case. The Life Cycle Costs per product are 20 euros (Table 5-39), the costs due to electricity in use-phase is only 5%[29]. The costs of energy consumption are insignificant especially for EPS of DIY power tools because they are used sparingly. Professional tools are in more frequent use but on the other hand their lifetime is significantly shorter, so the electricity consumption and costs over lifetime are also small.

28 Weighed average of DIY and professional power tool charger prices (=0.7*15+0.3*30)

29 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

Table 5-39 – LCC per product for power tool charger base-case

	Base Case: Power tool charger *Item*	LCC new product
D	Product price	20 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	1 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**20** €

5.7.4 EU TOTALS

5.7.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of the new power tool chargers produced in 2005 over their lifetime are listed in the Table 5-40 below.

Table 5-40 – EU total impact of new power tool chargers over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base Case: Power tool charger							02.10.2006	Kschi		
	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	kt			**3**			3	0	**3**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**1**			0	1	**1**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**5**			2	2	**5**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**8**			5	3	**8**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	**3**	**1**	**1**	0	0	**0**	**5**
9	of which, electricity (in primary PJ)	PJ	1	0	**1**	**0**	**1**	0	0	**0**	**2**
10	Water (process)	mln. m3	1	0	**1**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	mln. m3	1	0	1	0	**3**	0	0	0	4
12	Waste, non-haz./ landfill	kt	14	1	**15**	**1**	**2**	1	1	**0**	**17**
13	Waste, hazardous/ incinerated	kt	1	0	**1**	**0**	**0**	5	0	**5**	**5**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	**2**	**0**	**0**	0	0	**0**	**2**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	1	0	**1**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

5.7.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of power tool chargers EPS in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the power tool charger stock is 8000 tons, the total annual energy consumption (GER) is 5 PJ.

Table 5-41 – EU total annual impact of the power tool charger stock (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***						Date	Author			
	Base Case: Power tool charger						02.10.2006	Kschi			
	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	kt			**3**			3	0	**3**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**1**			0	1	**1**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**5**			2	2	**5**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**8**			5	3	**8**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	**3**	**1**	**1**	0	0	**0**	**5**
9	of which, electricity (in primary PJ)	PJ	1	0	**1**	**0**	**1**	0	0	**0**	**2**
10	Water (process)	mln. m3	1	0	**1**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	mln. m3	1	0	**1**	**0**	**3**	0	0	**0**	**4**
12	Waste, non-haz./ landfill	kt	14	1	**15**	**1**	**2**	1	1	**0**	**17**
13	Waste, hazardous/ incinerated	kt	1	0	**1**	**0**	**0**	5	0	**5**	**5**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	**2**	**0**	**0**	0	0	**0**	**2**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	1	0	**1**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Table 5-42 – Summary of EU total annual impact of power tool charger stock

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Power tool charger		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**5**	PJ
of which, electricity	0.2	TWh
Water (process)*	0	mln.m3
Waste, non-haz./ landfill*	17	kton
Waste, hazardous/ incinerated*	5	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**2**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**1**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4
*=caution: low accuracy for production phase		

As presented in the Table 5-43 below, the annual consumer expenditure for the 2005 stock of power tool chargers are in the range of 290 million Euros for EU-25, 94% of which is contributed to the product price[30].

Table 5-43 – EU total annual consumer expenditure for power tool chargers

	Base Case: Power tool charger *Item*	**total annual consumer expenditure in EU25**
D	Product price	273 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	17 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**290** mln.€

30 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.8. ‘PRINTER EPS’ BASE-CASE

5.8.1 PRODUCT-SPECIFIC INPUTS

The base-case on printer EPS is an average of two products. Both – as common for this segment – are in switched-mode technology. BOM was already presented in section 4.1.2. The use phase electricity consumption was

The use phase electricity consumption, as estimated in section 4.3.2, is calculated with a rated output of 17.5 W, an average efficiency of 75% and a load profile as defined in task 3, consumer behaviour[31].

5.8.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

The following table shows the summarized results of the generic data set for external power supplies for printers[32]. The impacts of the use phase were calculated with an average product lifetime of 4 years.

Table 5-44 – EIA for ‘printer EPS’ base-case

Nr	Life cycle Impact per product:									Date	Author
0	Base Case: Printer EPS									09.10.2006	Kschi

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			19			17	2	19	0
2	TecPlastics	g			52			47	5	52	0
3	Ferro	g			1			0	1	1	0
4	Non-ferro	g			19			1	18	19	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			87			46	41	87	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			179			111	68	179	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	47	14	61	53	544	8	9	-1	656
9	of which, electricity (in primary MJ)	MJ	14	2	16	0	543	0	5	-5	555
10	Water (process)	ltr	11	1	12	0	36	0	4	-4	44
11	Water (cooling)	ltr	15	4	19	0	1449	0	1	-1	1466
12	Waste, non-haz./ landfill	g	415	18	433	52	634	11	14	-3	1116
13	Waste, hazardous/ incinerated	g	29	0	30	1	13	105	5	100	144
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	3	1	3	5	24	1	1	0	32
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	27	5	31	12	140	1	4	-3	181
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	0	0	0	0	1
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	4	0	0	0	4
19	Heavy Metals	mg Ni eq.	4	0	4	3	9	2	1	1	18
	PAHs	mg Ni eq.	11	0	11	3	1	0	0	0	15
20	Particulate Matter (PM, dust)	g	3	1	4	1	3	10	0	10	18
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	6	0	6	0	4	1	3	-2	8
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

31 =((1/0.75)-1)*(23.9*0.25*0.0175+0.1*1*0.0175)

32 For detailed results for this base-case see Table 5A1-4 in the Annexes.

The energy consumption in the use phase is split up as follows:

1.8 % full-load efficiency losses (printing)

98.2 % low load losses (printer in stand-by)

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency (at low load with preference)**
2. Reducing PCB size
3. Reducing copper weight in cables
4. Reducing weight / size of coils / transformers

5.8.3 Base-case Life Cycle Costs

For the Life Cycle Cost calculation, a product price of 12.50 is taken according to the power range.

The Life Cycle Costs per product are 19 Euros (Table 5-45), approximately 33% of which comes from the electricity i.e. power losses.[33]

Table 5-45 – LCC per product for EPS for printers

	Base Case: Printer EPS *Item*	LCC new product
D	Product price	13 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	6 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**19** €

5.8.4 EU Totals

5.8.4.1 Total life cycle impacts

The EU total impact of EPS for printers produced in 2005 over their lifetime is listed in the table below. Total weight of the EPS is 5000 tons, the total energy consumption (GER) is 20 PJ.

33 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

Table 5-46 – EU total impact of new ‘printer EPS’ over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:								Date	Author	
0	Base Case: Printer EPS							09.10.2006		Kschi	
	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	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**2**			1	0	**2**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**1**			0	1	**1**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**3**			1	1	**3**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**5**			3	2	**5**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	**2**	**2**	**16**	0	0	**0**	**20**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**16**	0	0	**0**	**17**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	1	0	**43**	0	0	0	**44**
12	Waste, non-haz./ landfill	kt	12	1	**13**	**2**	**19**	0	0	**0**	**33**
13	Waste, hazardous/ incinerated	kt	1	0	**1**	**0**	**0**	3	0	**3**	**4**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**4**	0	0	**0**	**5**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.8.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of printer EPS in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the printer EPS stock is 5000 tons, the total annual energy consumption (GER) is 21 PJ.

Table 5-47 – EU total annual impact of the printer EPS stock (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***								Date	Author	
	Base Case: Printer EPS								09.10.2006	Kschi	
	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	kt			1			1	0	1	0
2	TecPlastics	kt			2			1	0	2	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			3			1	1	3	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			5			3	2	5	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	2	2	18	0	0	0	21
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	18	0	0	0	18
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	1	0	48	0	0	0	49
12	Waste, non-haz./ landfill	kt	12	1	13	2	21	0	0	0	36
13	Waste, hazardous/ incinerated	kt	1	0	1	0	0	3	0	3	4
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	5	0	0	0	6
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

Table 5-48 – Summary EU total annual impacts of the printer EPS stock

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Printer EPS		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**21**	PJ
of which, electricity	1,8	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	36	kton
Waste, hazardous/ incinerated*	4	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**1**	mt CO2eq.
Acidifying agents (AP)	**6**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**1**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4
*=caution: low accuracy for production phase		

As presented in the table below, the annual consumer expenditure for the 2005 stock of printers (incl. flatbed scanners) are in the range of 609 million Euro for EU-25, thereof 234 million Euro on electricity (power losses).

Table 5-49 – EU total annual consumer expenditure for printer EPS stock

	Base Case: Printer EPS *Item*	**total annual consumer expenditure in EU25**	
D	Product price	375	mln.€
E	Installation/ acquisition costs (if any)	0	mln.€
F	Fuel (gas, oil, wood)	0	mln.€
F	Electricity	234	mln.€
G	Water	0	mln.€
H	Aux. 1: None	0	mln.€
I	Aux. 2 :None	0	mln.€
J	Aux. 3: None	0	mln.€
K	Repair & maintenance costs	0	mln.€
	Total	**609**	mln.€

5.9. 'TRANSFORMER FOR HALOGEN LIGHTING (MAGNETIC)' BASE-CASE

5.9.1 PRODUCT-SPECIFIC INPUTS

Bill of Materials data for magnetic transformers for halogen lighting, which was already presented in section 4.1.2, is based on one exemplary magnetic transformer of 60 W. Transformers for halogen lighting span a broad range of output power, but 60 W is dominating the market, it can be considered as the best representative product case. The use phase electricity consumption is calculated with an average efficiency of 80%, as presented in section 4.3.2.

5.9.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

From the environmental assessment below (Table 5-50), which was calculated with an average 10 year product lifetime, it is evident, that for halogen lighting transformers the – by far – most important environmental aspect is the energy consumption in the use phase. In almost all categories the use phase is dominant and contributes to total energy consumption for example by almost 90%.

Table 5-50 – EIA for 'halogen lighting magnetic transformer' base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: Magnetic Transformer for Halogen Lighting							17.11.2006	KSchi		

	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			**60**			54	6	**60**	**0**
2	TecPlastics	g			**200**			180	20	**200**	**0**
3	Ferro	g			**0**			0	0	**0**	**0**
4	Non-ferro	g			**0**			0	0	**0**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**990**			743	248	**990**	**0**
7	Misc.	g			**15**			1	14	**15**	**0**
	Total weight	g			**1265**			977	288	**1265**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	410	138	**548**	**54**	**4604**	37	51	**-14**	**5192**
9	of which, electricity (in primary MJ)	MJ	9	10	**19**	**0**	**4599**	0	29	**-29**	**4589**
10	Water (process)	ltr	42	12	**54**	**0**	**307**	0	26	**-26**	**335**
11	Water (cooling)	ltr	143	38	**181**	**0**	**12266**	0	6	**-6**	**12441**
12	Waste, non-haz./ landfill	g	731	139	**870**	**52**	**5341**	78	84	**-6**	**6258**
13	Waste, hazardous/ incinerated	g	67	4	**71**	**1**	**107**	482	32	**449**	**628**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	23	9	**32**	**5**	**201**	3	3	**-1**	**237**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	152	51	**203**	**13**	**1186**	5	23	**-17**	**1385**
17	Volatile Organic Compounds (VOC)	g	0	3	**3**	**0**	**2**	0	0	**0**	**5**
18	Persistent Organic Pollutants (POP)	ng i-Teq	2	0	**2**	**0**	**30**	1	0	**0**	**33**
19	Heavy Metals	mg Ni eq.	8	1	**9**	**3**	**79**	10	4	**6**	**97**
	PAHs	mg Ni eq.	197	3	**199**	**3**	**11**	0	3	**-3**	**210**
20	Particulate Matter (PM, dust)	g	38	15	**53**	**1**	**26**	47	1	**46**	**126**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	72	0	**72**	**0**	**30**	3	16	**-13**	**89**
22	Eutrophication	g PO4	2	1	**3**	**0**	**0**	0	0	**0**	**3**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency**
2. Reducing weight / size of coils / transformer

For the alternative scenario with the mains switch on the secondary side of the transformer (no-load losses for 16 hours/day), the power losses under load are still the dominating aspect, but no-load causes one third of all power consumption in the use phase. The total energy consumption including this no-load scenario is 7645 MJ compared to 5192 MJ in the base case scenario, meaning a total energy consumption throughout the lifetime of one unit of +47%.

5.9.3 BASE-CASE LIFE CYCLE COSTS

An average product price of 20.00 Euros is assumed. The Life Cycle Costs per product are 66 Euros (Table 5-51), 70% of which comes from the electricity.

Table 5-51 – LCC per product for the 'magnetic transformer for halogen lighting'

	Base Case: Magnetic Transformer for Halogen Lighting *Item*	LCC new product
D	Product price	20 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	46 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**66** €

The alternative scenario with no-load losses results in the electricity costs of 71 Euros and total LCC of 91 Euros.

5.9.4 EU TOTALS

The following data on EU totals refers to the base case scenario of transformers which are operated with a switch on the primary side only.

5.9.4.1 TOTAL LIFE CYCLE IMPACTS

The total market for transformers for halogen lighting is around 20 million units, thereof approx. 30% magnetic ones. Consequently, 6 million units are taken into account for this base-case.

The EU total life cycle environmental impacts of the new halogen lighting transformers produced in 2005 over their lifetime are listed in the Table 5-52 below. Total weight of these transformers is 8000 tons, the total energy consumption (GER) is 31 PJ.

Table 5-52 – EU total impact of new EPS for magnetic transformers for halogen lighting over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base Case: Magnetic Transformer for Halogen Lighting							17.11.2006	KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			6			4	1	6	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			8			6	2	8	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	2	1	3	0	28	0	0	0	31
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	28	0	0	0	28
10	Water (process)	mln. m3	0	0	0	0	2	0	0	0	2
11	Water (cooling)	mln. m3	1	0	1	0	74	0	0	0	75
12	Waste, non-haz./ landfill	kt	4	1	5	0	32	0	1	0	38
13	Waste, hazardous/ incinerated	kt	0	0	0	0	1	3	0	3	4
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	7	0	0	0	8
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

5.9.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of halogen lighting transformers in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the halogen lighting transformer stock is 8000 tons, the total annual energy consumption (GER) is 54 PJ.

Table 5-53 – EU total annual impact of the stock of halogen lighting magnetic transformers (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base Case: Magnetic Transformer for Halogen Lighting							17.11.2006	KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			6			4	1	6	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			8			6	2	8	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	2	1	3	0	51	0	0	0	54
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	51	0	0	0	51
10	Water (process)	mln. m3	0	0	0	0	3	0	0	0	4
11	Water (cooling)	mln. m3	1	0	1	0	135	0	0	0	136
12	Waste, non-haz./ landfill	kt	4	1	5	0	59	0	1	0	64
13	Waste, hazardous/ incinerated	kt	0	0	0	0	1	3	0	3	4
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	2	0	0	0	2
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	13	0	0	0	14
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	1	0	0	0	1
	PAHs	ton Ni eq.	1	0	1	0	0	0	0	0	1
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Table 5-54 – Summary of EU total annual impact of the stock of halogen lighting magnetic transformers

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Magnetic Transformer for Halogen Lighting		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**54**	PJ
of which, electricity	4,8	TWh
Water (process)*	4	mln.m3
Waste, non-haz./ landfill*	64	kton
Waste, hazardous/ incinerated*	4	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**2**	mt CO2eq.
Acidifying agents (AP)	**14**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**1**	ton Ni eq.
PAHs	**1**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	1	ton Hg/20
Eutrophication (EP)	0	kt PO4
*=caution: low accuracy for production phase		

As presented in the Table 5-55 below, the annual consumer expenditure for the 2005 stock of halogen lighting transformers are in the range of 775 million Euros for EU-25, thereof 655 million Euros (85%) on electricity, i.e. power losses[34].

Table 5-55 – EU total annual consumer expenditure for halogen lighting magnetic transformers

	Base Case: Magnetic Transformer for Halogen Lighting *Item*	**total annual consumer expenditure in EU25**
D	Product price	120 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	655 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**775** mln.€

34 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.10. ‘TRANSFORMER FOR HALOGEN LIGHTING (ELECTRONIC)’ BASE-CASE

5.10.1 PRODUCT-SPECIFIC INPUTS

Bill of Materials data for electronic transformers for halogen lighting is based on one exemplary magnetic transformer of 60 W (see section 4.1.2), which can be considered as the best representative output power. The use phase electricity consumption is calculated with an average efficiency of 92.5%, as presented in section 4.3.2.

5.10.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

From the environmental assessment below (Table 5-38), which was calculated with an average 10 year product lifetime, it is evident, that for halogen lighting electronic transformers, as for the magnetic ones, the most important environmental aspect is the **energy consumption in the use phase**. However, in absolute terms, the energy consumption of an electronic transformer is significantly lower than that of magnetic transformer (see the previous base-case.

Table 5-56 – EIA for ‘electronic transformer of halogen lighting’ base-case

Nr	Life cycle Impact per product:							Date	Author		
0	Base Case: Electronic Transformer for Halogen Lighting					17.11.2006			KSchi		

	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			**30**			27	3	**30**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**0**			0	0	**0**	**0**
4	Non-ferro	g			**66**			3	62	**66**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**127**			67	60	**127**	**0**
7	Misc.	g			**5**			0	5	**5**	**0**
	Total weight	g			**228**			97	130	**228**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	65	18	**83**	**53**	**1492**	7	11	**-4**	**1624**
9	of which, electricity (in primary MJ)	MJ	8	2	**10**	**0**	**1492**	0	7	**-7**	**1494**
10	Water (process)	ltr	11	1	**13**	**0**	**100**	0	6	**-6**	**106**
11	Water (cooling)	ltr	12	5	**17**	**0**	**3978**	0	1	**-1**	**3993**
12	Waste, non-haz./ landfill	g	378	23	**401**	**52**	**1733**	14	20	**-6**	**2180**
13	Waste, hazardous/ incinerated	g	37	1	**37**	**1**	**35**	87	8	**79**	**152**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	4	1	**5**	**5**	**65**	0	1	**0**	**74**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	29	6	**35**	**12**	**384**	1	5	**-4**	**428**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**1**	0	0	**0**	**1**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	**1**	**0**	**10**	0	0	**0**	**11**
19	Heavy Metals	mg Ni eq.	3	1	**4**	**3**	**26**	2	1	**1**	**33**
	PAHs	mg Ni eq.	27	0	**27**	**3**	**3**	0	1	**-1**	**32**
20	Particulate Matter (PM, dust)	g	5	2	**7**	**1**	**8**	8	0	**8**	**24**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	10	0	**10**	**0**	**10**	1	4	**-3**	**17**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency**
2. Reducing weight / size of coils / transformer

For the alternative scenario with the mains switch on the secondary side of the transformer (no-load losses for 16 hours/day), the power losses under load remain by far the dominating aspect. No-load losses increase the total power consumption power consumption in the use phase by 8%. The total energy consumption including this no-load scenario is 1747 MJ compared to 1624 MJ in the base case scenario. The comparison with the magnetic transformer case shows, that no-load can be a significant aspect for magnetic transformers, for electronic transformers it is a much less relevant aspect.

5.10.3 BASE-CASE LIFE CYCLE COSTS

An average product price of 20.00 Euros is assumed. The Life Cycle Costs per product are 35 Euros (Table 5-57), 43% of which comes from the electricity.

Table 5-57 – LCC per product for the 'electronic transformer for halogen lighting' base-case

	Base Case: Electronic Transformer for Halogen Lighting *Item*	LCC new product
D	Product price	20 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	15 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	35 €

The alternative scenario with no-load losses results in electricity costs of 16 Euros and total LCC of 36 Euro.

5.10.4 EU TOTALS

The following data on EU totals refers to the base case scenario of transformers which are operated with a switch on the primary side only.

5.10.4.1 TOTAL LIFE CYCLE IMPACTS

The total market for transformers for halogen lighting is 20 million units, thereof approx. 70% electronic ones. Consequently, 14 million units are taken into account for this base-case.

The EU total life cycle environmental impacts of the new halogen lighting transformers (electronic) produced in 2005 over their lifetime are listed in Table 5-58 below.

Total weight of the electronic transformers is 3000 tons, the total energy consumption (GER) is 23 PJ.

Table 5-58 – EU total impact of new electronic transformers for halogen lighting over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base Case: Electronic Transformer for Halogen Lighting					17.11.2006			KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			2			1	1	2	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			3			1	2	3	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	1	21	0	0	0	23
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	21	0	0	0	21
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	56	0	0	0	56
12	Waste, non-haz./ landfill	kt	5	0	6	1	24	0	0	0	31
13	Waste, hazardous/ incinerated	kt	1	0	1	0	0	1	0	1	2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	5	0	0	0	6
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

5.10.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of electronic halogen lighting transformers in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of these halogen lighting transformers' stock is 3 tons, the total annual energy consumption (GER) is 18 PJ.

Table 5-59 – EU total annual impact of stock of electronic halogen lighting transformers (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base Case: Electronic Transformer for Halogen Lighting							17.11.2006	KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			2			1	1	2	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			3			1	2	3	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	1	16	0	0	0	18
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	16	0	0	0	16
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	44	0	0	0	44
12	Waste, non-haz./ landfill	kt	5	0	6	1	19	0	0	0	25
13	Waste, hazardous/ incinerated	kt	1	0	1	0	0	1	0	1	2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	4	0	0	0	5
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

Table 5-60 – Summary of EU total annual impact of the stock of electronic halogen lighting transformers

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Electronic Transformer for Halogen Lighting		
main life cycle indicators	**value**	**unit**
Total Energy (GER)	**18**	PJ
of which, electricity	1,6	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	25	kton
Waste, hazardous/ incinerated*	2	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**1**	mt CO2eq.
Acidifying agents (AP)	**5**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4
*=caution: low accuracy for production phase		

As presented in the Table 5-61 below, the annual consumer expenditure for the 2005 stock of electronic halogen lighting transformers are in the range of 493 million Euros for EU-25, thereof 213 million Euros on electricity, i.e. power losses[35].

Table 5-61 – EU total annual consumer expenditure for the electronic halogen lighting transformers

	Base Case: Electronic Transformer for Halogen Lighting *Item*	**total annual consumer expenditure in EU25**	
D	Product price	280	mln.€
E	Installation/ acquisition costs (if any)	0	mln.€
F	Fuel (gas, oil, wood)	0	mln.€
F	Electricity	213	mln.€
G	Water	0	mln.€
H	Aux. 1: None	0	mln.€
I	Aux. 2 :None	0	mln.€
J	Aux. 3: None	0	mln.€
K	Repair & maintenance costs	0	mln.€
	Total	**493**	mln.€

35 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.11. 'LAPTOP EPS (WITHOUT PFC)' BASE-CASE

5.11.1 PRODUCT-SPECIFIC INPUTS

The analysis of the EPS without power factor correction (PFC) is based on two units of 65 W output, which were provided by two of the leading laptop OEMs. The average Bill of Materials was presented in section 4.1.2.

The use phase is calculated with an average efficiency of 82%, no-load losses of 1.25 W and a load profile as defined in task 3, consumer behaviour[36] (see section 4.3.2)

5.11.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

From the environmental assessment below (Table 5-62)[37], it is evident that for laptop EPS the – by far – most important environmental aspect is the energy consumption in the use phase. In almost all categories the use phase is dominant and contributes to primary energy consumption for example by more than 90%. The impacts of a use phase were calculated with an average 5 year product lifetime

36 =((1/0.82)-1)*(1*0.25*0.065+4*0.5*0.065+2*0.75*0.065+3.5*1*0.065)

37 See Table 5A1- **5** in the Annexes for the detailed results for this base-case.

Table 5-62 – EIA for the base-case ‘EPS for laptops (without PFC)’

Nr	Life cycle Impact per product:							Date	Author		
0	Base case: Laptop EPS 65W						3.11.06		KSchi		
	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			**37**			33	4	**37**	**0**
2	TecPlastics	g			**48**			43	5	**48**	**0**
3	Ferro	g			**2**			0	1	**2**	**0**
4	Non-ferro	g			**80**			4	76	**80**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**96**			48	48	**96**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**263**			129	134	**263**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	69	17	**85**	**53**	**2306**	9	10	**-1**	**2443**
9	of which, electricity (in primary MJ)	MJ	24	3	**27**	**0**	**2306**	0	6	**-6**	**2327**
10	Water (process)	ltr	12	1	**14**	**0**	**154**	0	5	**-5**	**162**
11	Water (cooling)	ltr	16	5	**20**	**0**	**6149**	0	1	**-1**	**6168**
12	Waste, non-haz./ landfill	g	1062	25	**1087**	**52**	**2684**	17	16	**0**	**3824**
13	Waste, hazardous/ incinerated	g	16	0	**16**	**1**	**53**	124	6	**118**	**189**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	4	1	**5**	**5**	**101**	1	1	**0**	**110**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	40	6	**46**	**12**	**594**	1	4	**-3**	**649**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**1**	0	0	**0**	**1**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	**1**	**0**	**15**	0	0	**0**	**16**
19	Heavy Metals	mg Ni eq.	7	0	**7**	**3**	**40**	3	1	**2**	**52**
	PAHs	mg Ni eq.	16	0	**16**	**3**	**5**	0	1	**-1**	**23**
20	Particulate Matter (PM, dust)	g	4	2	**5**	**1**	**13**	12	0	**12**	**31**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	11	0	**11**	**0**	**15**	1	3	**-2**	**23**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

The energy consumption in the use phase is split up as follows:

86 % On-mode efficiency losses

14 % Off-mode losses

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency**
2. Reducing no-load losses
3. Reducing PWB size
4. Reducing weight of copper cable
5. Reducing weight / size of coils / transformer and electrolytic capacitors

5.11.3 BASE-CASE LIFE CYCLE COSTS

According to the power range a product price of 30.00 Euro is used. This makes up almost half of the total Life Cycle Costs of 56 Euros (Table 5-63).

Table 5-63 – LCC per product for laptop EPS (without PFC)

	Base case: Laptop EPS 65W *Item*	LCC new product
D	Product price	30 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	26 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**56** €

5.11.4 EU TOTALS

5.11.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total life cycle environmental impacts of the new laptop EPS (without PFC) produced in 2005 over their lifetime are listed in the Table 5-64 below. Total weight of the EPS is 4 000 tons, the total energy consumption (GER) is 39 PJ.

Table 5-64 – EU total impact of new laptop EPS (without PFC) over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:						Date	Author			
0	Base case: Laptop EPS 65W						3.11.06		KSchi		
	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	kt			1			1	0	1	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			2			1	1	2	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			4			2	2	4	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	1	37	0	0	0	39
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	37	0	0	0	37
10	Water (process)	mln. m3	0	0	0	0	2	0	0	0	3
11	Water (cooling)	mln. m3	0	0	0	0	98	0	0	0	99
12	Waste, non-haz./ landfill	kt	17	0	17	1	43	0	0	0	61
13	Waste, hazardous/ incinerated	kt	0	0	0	0	1	2	0	2	3
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	2	0	0	0	2
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	10	0	0	0	10
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	1	0	0	0	1
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

5.11.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of laptop EPS (without PFC) the total environmental impacts in 2005 are listed in the tables below. Total weight of the stock of these EPS is 4000 tons, the total annual energy consumption (GER) is 43 PJ.

Table 5-65 – EU total annual impact of the stock of 'laptop EPS (without PFC)' (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base case: Laptop EPS 65W							3.11.06	KSchi		
	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	kt			1			1	0	1	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			2			1	1	2	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			4			2	2	4	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	1	41	0	0	0	43
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	41	0	0	0	41
10	Water (process)	mln. m3	0	0	0	0	3	0	0	0	3
11	Water (cooling)	mln. m3	0	0	0	0	108	0	0	0	109
12	Waste, non-haz./ landfill	kt	17	0	17	1	47	0	0	0	65
13	Waste, hazardous/ incinerated	kt	0	0	0	0	1	2	0	2	3
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	2	0	0	0	2
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	10	0	0	0	11
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	1	0	0	0	1
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	1
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

Table 5-66 – Summary of EU total annual impact of the stock of 'laptop EPS (without PFC)'

Table . Summary Environmental Impacts EU-Stock 2005, Base case: Laptop EPS 65W

main life cycle indicators	value	unit
Total Energy (GER)	**43**	PJ
of which, electricity	3,9	TWh
Water (process)*	3	mln.m3
Waste, non-haz./ landfill*	65	kton
Waste, hazardous/ incinerated*	3	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**2**	mt CO2eq.
Acidifying agents (AP)	**11**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**1**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**1**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As presented in the Table 5-67 below, the annual consumer expenditure for the 2005 stock of laptop EPS (without PFC) are in the range of 1006 million Euros for EU-25, thereof 526 million Euros on electricity, i.e. power losses[38].

Table 5-67 – EU total annual consumer expenditure the 'laptop EPS (without PFC)' stock

	Base case: Laptop EPS 65W *Item*	total annual consumer expenditure in EU25
D	Product price	480 mln.€
E	Installation/ acquisition costs (if any)	0 mln.€
F	Fuel (gas, oil, wood)	0 mln.€
F	Electricity	526 mln.€
G	Water	0 mln.€
H	Aux. 1: None	0 mln.€
I	Aux. 2 :None	0 mln.€
J	Aux. 3: None	0 mln.€
K	Repair & maintenance costs	0 mln.€
	Total	**1006** mln.€

38 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

5.12. 'LAPTOP EPS (WITH PFC)' BASE-CASE

5.12.1 PRODUCT-SPECIFIC INPUTS

The analysis of the laptop segment with power factor correction (PFC) is based on one best selling 90 W product from a leading laptop manufacturer. Two different base-cases for a laptop EPS (see also the previous section) are included in order to crosscheck the influence of the power factor correction on electronics layout as well as efficiency and no-load losses. The PFC is required for the EPS from 75 W input upwards.

The Bill of Materials was presented in section 4.1.2. The use phase is calculated with an average an average efficiency of 82%, no-load losses of 1.25 W[39] and a load profile as defined in task 3, consumer behaviour[40]. (see section 4.3.2)

5.12.2 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

As for laptop EPS without PFC (previous section), the most important environmental aspect is the energy consumption in the use phase. In almost all categories the use phase is dominant and contributes to primary energy consumption, for example, by more than 90%. (Table 5-68)[41] The use phase is calculated with an average 5 year product lifetime.

39 Notice that this is a conscious abstraction of reality for this power segment, but the exemplary BOM is correlated with an EPS with an average efficiency of 85.2% and no-load losses of approx. 0.6 W.

40 =((1/0.82)-1)*(1*0.25*0.09+4*0.5*0.09+2*0.75*0.09+3.5*1*0.09)

41 For more detailed results for this base-case, see Table 5A1- **6** in the Annexes.

Table 5-68 – EIA per product for the base-case 'EPS (with PFC) for laptops'

Nr	Life cycle Impact per product:		Date	Author
0	Base case: Laptop EPS 90 W		07.11.2006	K.Schi.

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			51			46	5	51	0
2	TecPlastics	g			73			66	7	73	0
3	Ferro	g			3			0	3	3	0
4	Non-ferro	g			93			5	88	93	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			176			90	86	176	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			396			206	190	396	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	90	28	118	52	3069	15	18	-3	3237
9	of which, electricity (in primary MJ)	MJ	11	4	15	0	3068	0	10	-10	3073
10	Water (process)	ltr	13	2	15	0	205	0	9	-9	211
11	Water (cooling)	ltr	24	8	31	0	8182	0	2	-2	8211
12	Waste, non-haz./ landfill	g	1355	39	1394	52	3571	25	29	-4	5013
13	Waste, hazardous/ incinerated	g	29	1	30	1	71	198	11	186	288
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	5	2	7	5	134	1	1	0	145
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	49	10	59	12	791	2	8	-6	856
17	Volatile Organic Compounds (VOC)	g	0	1	1	0	1	0	0	0	2
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	1	0	20	0	0	0	22
19	Heavy Metals	mg Ni eq.	7	0	8	3	53	4	1	3	66
	PAHs	mg Ni eq.	32	0	32	3	6	0	1	-1	40
20	Particulate Matter (PM, dust)	g	7	3	9	2	17	19	0	19	47
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	18	0	18	0	20	1	6	-5	33
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

The total energy consumption in the use phase is split up as follows:

89 % On-mode efficiency losses

11 % Off-mode losses

Based on the assessment results focus areas for improvements have to be discussed in the following order:

1. **Increasing energy efficiency**
2. Reducing no-load losses
3. Reducing PWB size
4. Reducing weight / size of coils / transformer and electrolytic capacitors

Compared to e.g. the DECT phone and mobile phone base-cases where also size / weight of coils / transformers / electrolytic capacitors is an issue, here this is due to the fact, that the power to be transformed just requires such large components whereas in the low power range linear technology is on the market.

5.12.3 BASE-CASE LIFE CYCLE COSTS

According to the power range, a product price of 30 Euros is assumed, as for the laptop EPS without power factor correction. In reality the PFC is likely to have an upward effect on the price. The total market for laptop EPS is 20 million units, thereof approx. 20% in the range with PFC. Consequently, 4 million units are taken into account for this base-case.

The Life Cycle Costs per product are 64 Euros (Table 5-69), electricity, i.e. power losses, being responsible for approximately half of the total consumer costs.[42]

Table 5-69 – LCC per product for laptop EPS (with PFC)

	Base case: Laptop EPS 90 W *Item*	LCC new product
D	Product price	30 €
E	Installation/ acquisition costs (if any)	0 €
F	Fuel (gas, oil, wood)	0 €
F	Electricity	34 €
G	Water	0 €
H	Aux. 1: None	0 €
I	Aux. 2 :None	0 €
J	Aux. 3: None	0 €
K	Repair & maintenance costs	0 €
	Total	**64** €

5.12.4 EU TOTALS

5.12.4.1 TOTAL LIFE CYCLE IMPACTS

The EU total impact of EPS with PFC for laptops produced in 2005 over their lifetime is listed in the table below. Total weight of these EPS is 2 000 tons, the total energy consumption (GER) is 13 PJ.

42 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

Table 5-70 – EU total impact of new EPS (with PFC) for laptops over their lifetime

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	Base case: Laptop EPS 90 W							07.11.2006	K.Schi.		
	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	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**1**			0	0	**1**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**2**			1	1	**2**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**12**	0	0	**0**	**13**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**12**	0	0	**0**	**12**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	0	0	**33**	0	0	0	33
12	Waste, non-haz./ landfill	kt	5	0	**6**	**0**	**14**	0	0	**0**	**20**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**3**	0	0	**0**	**3**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

5.12.4.2 ANNUAL IMPACT OF THE STOCK

For the stock of laptop EPS (with PFC) in 2005 (produced, in use, discarded), the EU total environmental impacts are listed in the tables below. Total weight of the laptop EPS (with PFC) stock is 2000 tons, the total annual energy consumption (GER) is 14 PJ.

Table 5-71 – EU total annual impact of stock of 'laptop EPS (with PFC)' (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	Base case: Laptop EPS 90 W							07.11.2006	K.Schi.		
	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	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**1**			0	0	**1**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**2**			1	1	**2**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**14**	0	0	**0**	**14**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**14**	0	0	**0**	**14**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**36**	0	0	0	**36**
12	Waste, non-haz./ landfill	kt	5	0	**6**	**0**	**16**	0	0	**0**	**21**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**3**	0	0	**0**	**4**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

Table 5-72 – Summary EU total annual impact of the stock of 'EPS for laptops (with PFC)'

Table . Summary Environmental Impacts EU-Stock 2005, Base Case: Laptop 90W

main life cycle indicators	value	unit
Total Energy (GER)	**14**	PJ
of which, electricity	1,3	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	21	kton
Waste, hazardous/ incinerated*	1	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**1**	mt CO2eq.
Acidifying agents (AP)	**4**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

As presented in the Table 5-73 below, the annual consumer expenditure for the 2005 stock of laptop EPS (with PFC) are in the range of 295 million Euros for EU-25, thereof 175 million Euros on electricity, i.e. power losses[43].

Table 5-73 – EY total annual consumer expenditure for the stock of laptop EPS (with PFC)

	Base case: Laptop EPS 90 W *Item*	**total annual consumer expenditure in EU25**	
D	Product price	120	mln.€
E	Installation/ acquisition costs (if any)	0	mln.€
F	Fuel (gas, oil, wood)	0	mln.€
F	Electricity	175	mln.€
G	Water	0	mln.€
H	Aux. 1: None	0	mln.€
I	Aux. 2 :None	0	mln.€
J	Aux. 3: None	0	mln.€
K	Repair & maintenance costs	0	mln.€
	Total	**295**	mln.€

43 The uncertainty on use patterns, especially the no-load times (task 3) has a significant impact on the actual LCC costs.

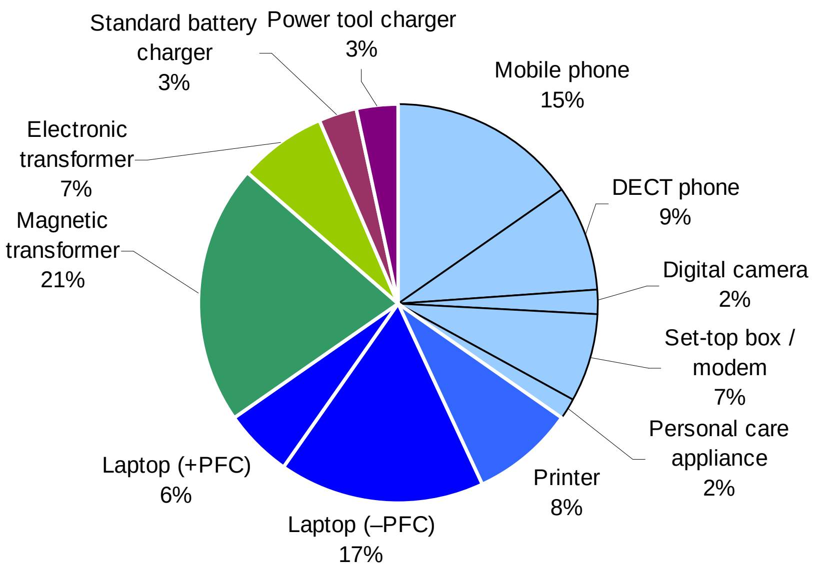
5.13. EU-25 TOTAL SYSTEM IMPACT

Summary of environmental impacts and life cycle costs of base-cases, as well as the lot 7 totals are presented in Table 5-74.

Regarding the environmental impacts of the 2005 stock, magnetic transformers for halogen lighting, mobile phones and laptop computers are the largest contributors to the total energy consumption (Figure 5-2). Regarding sub-product groups, EPS of the low power range make up approximately one third of the total. In general, battery chargers (standard battery chargers and cordless power tool chargers) contribute only few percent.

It is important to note that a large contribution does not necessarily mean that a product (group) consumer a lot of energy per unit or that it has a low energy efficiency, and vice versa. For example, mobile phone EPS show up due to their large stock rather than their poor efficiency or high energy consumption per unit.

Figure 5-2 – Total energy consumption (GER in PJ) of the Lot 7 stock (2005) per base-case



Impacts in all categories are mainly linked to energy consumption in the use phase (standard BC and DIY tool chargers make an exception due to their low use times). Consequently, regarding the relative importance of the base-cases, the total energy consumption correlates closely with other impacts (Figure 5-3).

Table 5-74 – Summary of environmental impacts and life cycle costs of the base-cases and the lot 7 totals

Lot 7 Total environmental impacts of 2005 stock in EU25														
Base-cases / Main life cycle indicators	Unit	EPS for Mobile phone	EPS for DECT phone	EPS for Digital camera	EPS for Set-top box / modem	EPS for Personal care appliance	EPS for Printer	EPS for Laptop (–PFC)	EPS for Laptop (+PFC)	Transformer for halogen lighting (Magnetic)	Transformer for halogen lighting (Electronic)	Standard battery charger	Power tool charger	Lot 7 TOTAL
Total Energy (GER)	PJ	39	23	4	19	4	21	43	14	54	18	8	5	254
of which, electricity	TWh	1.8	1.7	0.2	1.3	0.3	1.8	3.9	1.3	4.8	1.6	0.5	0.2	19
Water (process)*	mln.m^3	2	1	0	1	0	1	3	1	4	1	1	0	16
Waste, non-haz./ landfill*	kton	90	35	24	26	8	36	65	21	64	25	24	17	436
Waste, hazardous/ incinerated*	kton	17	5	2	5	1	4	3	1	4	2	3	5	52
Emissions (Air)														
Greenhouse Gases in GWP100	mt CO_2eq.	2.4	1.1	0.3	0.9	0.2	1.0	1.9	0.6	2.4	0.8	0.4	0.3	13
Acidifying agents (AP)	kt SO_2eq.	11.0	6.1	1.4	5.1	1.2	5.9	11.3	3.7	14.2	4.8	2.5	1.9	69
Volatile Org. Compounds (VOC)	kt	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Persistent Org. Pollutants (POP)	g i-Teq.	0.3	0.1	0.0	0.1	0.0	0.1	0.3	0.1	0.3	0.1	0.1	0.0	2
Heavy Metals (HM)	ton Ni eq.	1.7	0.5	0.2	0.4	0.1	0.6	0.9	0.3	1.0	0.4	0.5	0.3	7
PAHs	ton Ni eq.	2.2	1.3	0.3	1.4	0.1	0.4	0.4	0.2	1.3	0.4	0.6	0.8	9
Particulate Matter (PM, dust)	kt	2.1	0.8	0.3	0.9	0.1	0.5	0.5	0.2	0.9	0.3	0.4	0.7	8
Emissions (Water)														
Heavy Metals (HM)	ton Hg/20	0.8	0.4	0.1	0.4	0.0	0.2	0.4	0.1	0.7	0.2	0.4	0.2	4
Eutrophication (EP)	kt PO_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
*=caution: low accuracy for production phase														
Lot 7 Total annual consumer expenditure in EU25 in 2005														
Product price	mln.€	942	105	234	149	35	375	480	120	120	280	300	273	3412
Electricity	mln.€	229	230	22	183	46	234	526	175	655	213	72	17	2601
TOTAL consumer expenditure	mln.€	1170	335	256	332	81	609	1006	295	775	493	612	290	6254

Note: The total consumer expenditure of Standard battery chargers includes 240 million Euros of consumables' costs (batteries)

Figure 5-3 – Base-cases' share of the environmental impacts of the 2005 EPS/BC stock: (a) non-hazardous waste/landfill, (b) acidifying agents (AP) and (c) persistent organic pollutants (POP)

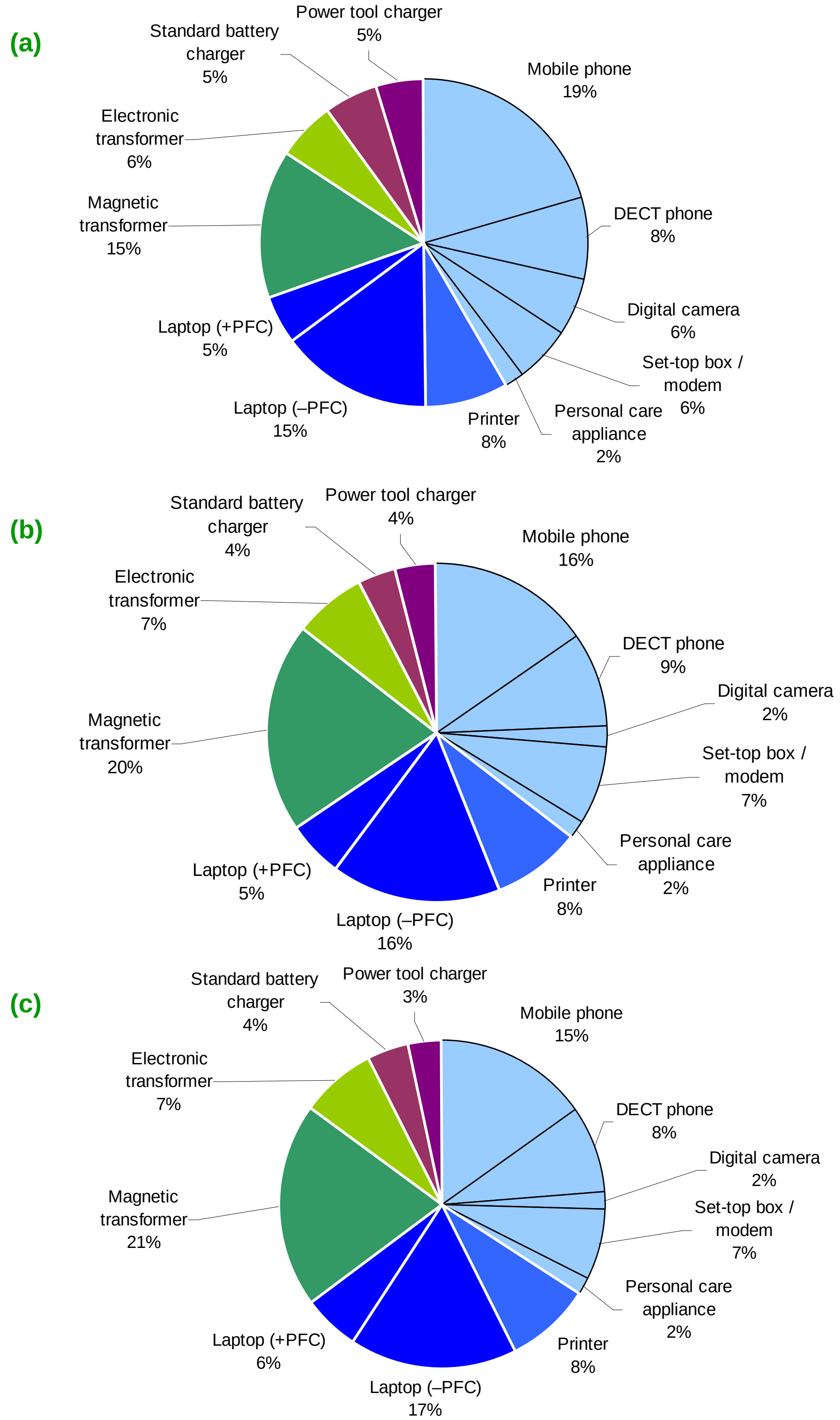
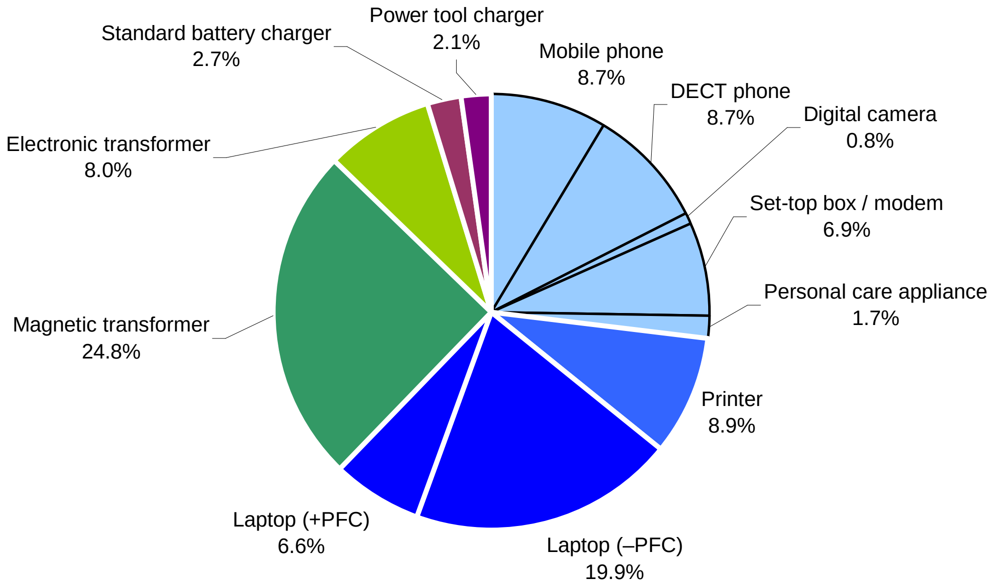


Figure 5-4 – Base-cases' share of the electricity costs of the 2005 EPS/BC stock



The total impacts of the EPS and BC covered in this preparatory study are very low compared to the total life cycle impacts of the products in EU-25, which have been estimated in the EIPRO study[44]. Global warming potential of EPS/BC is 0.27% and acidification of 0.16% of the EIPRO total, while eutrophication potential even more insignificant (less than 0.0001%). Other impact categories cannot be compared with the EIPRO study as some of the categories have not been covered by the study or different units were used.

Base-cases are estimated to cover roughly 90% of the whole market of products falling into the scope of lot 7 (Figure 5-5). The extrapolated total annual energy consumption of the products covered by the lot 7 scope is approximately 280 PJ, of which electricity 21 TWh. The annual consumer expenditure is 6872 million euros, 42% of which is due to electricity consumption.

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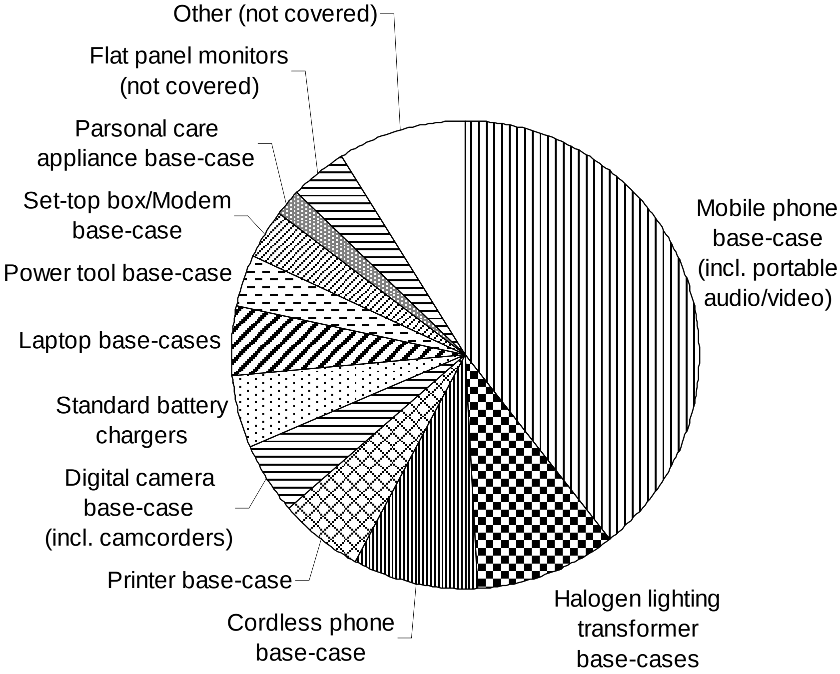
[44] EC (2006) Environmental Impact of Products (EIPRO) – Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Available at http://ec.europa.eu/environment/ipp/pdf/eipro_report.pdf (viewed 21/01/2007)

Figure 5-5 – Market coverage of the base-cases



In this study, it was assumed that the consumer does not leave the battery chargers and the EPS which are used to charge a battery (e.g. for mobile phones and laptops) plugged in continuously. An opposite assumption would result in much higher environmental impacts and LCC.

The systems analysis aspects were discussed in section 4.4 (task 4). One of the most important elements of the "system", in which EPS and BC are embedded, are the end-appliances. However, within this study it is not feasible to extend the environmental and LCC assessments to cover all these appliances. Many of them are a subject of on-going or future EuP preparatory studies, which will assess them in detail. It is clear that the impacts of the overall system, covering all end-applications, will be many times higher than the impacts of external power supplies and battery chargers alone.

ANNEX 5-1 – DETAILED EIA RESULTS FOR SOME BASE-CASES

The results of the environmental assessment are provided with two perspectives,

- a product view (applied in detail for selected base-cases) and
- a EU 25 market view

The **detailed product view**[45] shows the results from the assessment of individual, respectively averaged products, for some of the base-cases. Such a product view facilitates an immediate identification, what are the environmentally relevant aspects of this kind of product. For a better overview, aspects contributing by more than 10% to the respective category are marked with an orange background, those contributing by 5-10% with a yellow background. All other fields are in grey. In the discussion among the environmental impact categories priority is given to primary energy consumption (GER), which largely corresponds with CO_2 emissions.

45 Based on the “RAW” spreadsheet of the EcoReport tool

Table 5A1- 1 – Detailed environmental assessment results for 'Mobile phone EPS' base-case

MATERIALS EXTRACTION & PRODUCTION

nr	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	Housing	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
2	Case	1,65	0,21	0,54	0,20	1,61	0,14	2,49	0,08	0,36	0,00	0,00	0,00	0,01	0,09	0,00	7,12
3	Case	0,91	0,07	0,44	0,09	1,59	0,10	0,88	0,03	0,17	0,00	0,00	0,00	0,02	0,03	0,02	6,06
4	Metal pins etc.	0,12	0,00	0,00	0,00	0,00	0,00	9,13	0,01	0,11	0,00	0,08	0,17	0,01	0,00	0,03	0,05
5	Steel	0,02	0,00	0,00	0,03	0,00	0,00	0,34	0,00	0,02	0,00	0,00	0,05	0,00	0,00	0,03	0,80
6	Electronic assembly	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
7	PWB	0,72	0,38	0,02	0,43	0,20	4,41	6,68	0,03	0,54	0,01	0,01	0,09	0,01	0,01	0,04	9,38
8	Big caps & coils (THT)	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
9	Capacitors (electrolytic)	0,85	0,00	0,00	0,08	0,12	0,04	1,34	0,05	0,32	0,00	0,00	0,02	0,46	0,08	0,17	0,02
11	Coils + transformers	9,49	0,00	0,00	0,86	1,36	0,49	14,88	0,54	3,51	0,00	0,05	0,19	5,07	0,88	1,84	0,18
14	IC's	0,06	0,05	0,00	0,04	0,01	0,05	0,13	0,00	0,06	0,00	0,00	0,01	0,00	0,00	0,00	0,31
15	SMD /LED's average	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
16	SMD Capacitors (ceramic, others)	0,35	0,34	0,00	0,11	0,00	0,02	0,34	0,02	0,19	0,00	0,00	0,05	0,00	0,01	0,00	0,26
17	SMD Resistors, inductor filter	0,94	0,91	0,00	0,29	0,00	0,04	0,89	0,05	0,51	0,00	0,00	0,13	0,00	0,02	0,00	0,69
18	Solder	0,14	0,12	0,00	0,04	0,00	0,00	0,14	0,01	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00
19	Miscellaneous	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	Diodes	1,17	0,90	0,00	0,82	0,14	0,86	2,35	0,08	1,09	0,00	0,01	0,25	0,00	0,03	0,01	5,76
21	Transistors	0,38	0,29	0,00	0,27	0,04	0,28	0,76	0,03	0,35	0,00	0,00	0,08	0,00	0,01	0,00	1,87
22	Resistors (THT)	0,87	0,85	0,00	0,27	0,00	0,04	0,83	0,05	0,48	0,00	0,00	0,12	0,00	0,01	0,00	0,64
23	Ferrite core	0,02	0,00	0,00	0,02	0,00	0,00	1,03	0,00	0,00	0,00	0,02	0,01	0,00	0,00	0,00	0,03
26	Cables	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	Copper wire	0,87	0,00	0,00	0,00	0,00	0,00	149,16	0,05	2,18	0,00	0,03	0,41	0,04	0,02	0,70	1,15
28	Isolation, strain relief	1,05	0,21	0,43	0,20	1,15	0,09	1,25	0,04	0,28	0,00	0,00	0,00	0,00	0,05	0,05	5,83
29	Plug, slot	0,30	0,10	0,00	0,12	0,41	0,03	0,50	0,02	0,30	0,00	0,00	0,06	0,00	0,02	0,05	10,47
30	Nylon	0,07	0,01	0,02	0,01	0,12	0,01	0,10	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,03	1,05
32	Miscellaneous	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
33	Heatsink	0,02	0,00	0,00	0,03	0,00	0,00	0,34	0,00	0,02	0,00	0,00	0,05	0,00	0,00	0,03	0,78
34	div.	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
35	Packaging	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
36	Cardboard	0,33	0,02	0,19	0,08	0,00	0,00	0,62	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	1,02
	TOTAL	20,35	4,47	1,64	3,99	6,76	6,60	194,17	1,09	10,57	0,02	0,22	1,71	5,62	1,29	3,01	53,48

	MANUFACTURING																
201	OEM Plastics Manufacturing (fixed)	1,75	**1,05**	0,06	**0,02**	0,50	**0,00**	5,49	**0,10**	0,42	**0,00**	0,00	**0,00**	**0,00**	0,06	**0,00**	1,02
202	Foundries Fe/Cu/Zn (fixed)	0,01	**0,00**	0,00	**0,00**	0,00	**0,00**	0,02	**0,00**	0,00	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,00
204	Sheetmetal Manufacturing (fixed)	0,02	**0,01**	0,00	**0,00**	0,00	**0,00**	0,05	**0,00**	0,00	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,01
205	PWB Manufacturing (fixed)	4,18	**0,10**	0,16	**0,38**	1,16	**0,14**	3,47	**0,28**	1,59	**0,10**	0,00	**0,03**	**0,08**	0,49	**0,01**	23,05
206	Other materials (Manufacturing already included)	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 percentage only)	0,00	**0,00**	0,00	**0,00**	0,00	**0,00**	0,05	**0,00**	0,00	**0,00**	0,00	**0,01**	**0,00**	0,00	**0,00**	0,00
	TOTAL	**5,95**	**1,17**	**0,22**	**0,40**	**1,67**	**0,14**	**9,08**	**0,38**	**2,02**	**0,10**	**0,01**	**0,04**	**0,08**	**0,55**	**0,01**	**24,09**
	DISTRIBUTION																
		51,50	**0,00**	0,00	**0,00**	0,00	**1,02**	51,36	**4,52**	12,00	**0,05**	0,29	**2,62**	**2,62**	0,26	**0,08**	1,36
208	Is it an ICT or Consumer Electronics product <15 kg ?	0,74	**0,00**	0,01	**0,00**	0,00	**0,01**	0,33	**0,06**	0,20	**0,01**	0,00	**0,02**	**0,01**	0,23	**0,00**	0,01
209	Is it an installed appliance (e.g. boiler)?	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
		0,12	**0,00**	0,00	**0,00**	0,00	**0,00**	0,08	**0,01**	0,02	**0,00**	0,00	**0,00**	**0,00**	0,05	**0,00**	0,00
210	Volume of packaged final product in m3	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
		0,01	**0,00**	0,00	**0,00**	0,00	**0,00**	0,01	**0,00**	0,00	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,00
	TOTAL	**52,38**	**0,00**	0,01	**0,00**	0,00	**1,03**	51,78	**4,59**	12,23	**0,06**	0,29	**2,64**	**2,63**	**0,54**	**0,08**	**1,37**
	USE PHASE																
		59,67	59,67	0,00	3,98	159,11	1,37	69,18	2,60	15,36	0,02	0,39	1,02	0,12	0,33	0,38	1,83
	TOTAL over Product Life	59,67	**59,67**	0,00	**3,98**	159,11	**1,37**	69,18	**2,60**	15,36	**0,02**	0,39	**1,02**	**0,12**	**0,33**	**0,38**	**1,83**
	Maintenance, Repairs, Service	0,26	**0,06**	0,02	**0,04**	0,08	**0,07**	2,03	**0,01**	0,13	**0,00**	0,00	**0,02**	**0,06**	**0,02**	**0,03**	**0,78**
225	No. of km over Product-Life	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
226	Spare parts (fixed, 1% of product materials & manuf.)	0,26	**0,06**	0,02	**0,04**	0,08	**0,07**	2,03	**0,01**	0,13	**0,00**	0,00	**0,02**	**0,06**	0,02	**0,03**	0,78
	TOTAL	**59,93**	59,72	0,02	4,02	159,19	1,44	71,21	2,62	15,49	0,02	0,39	1,04	0,17	0,35	0,41	2,61
	DISPOSAL/RECYCLING																
	Disposal: Environmental Costs perkg final product	4,06	**0,00**	0,00	**0,00**	0,00	**54,83**	6,19	**0,30**	0,61	**0,01**	0,04	**1,09**	**0,00**	**5,22**	**0,34**	19,43
231	Landfill (fraction products not recovered) in g en %	0,34	**0,00**	0,00	**0,00**	0,00	**0,00**	6,17	**0,03**	0,05	**0,00**	0,04	**0,10**	**0,00**	0,45	**0,03**	1,63
232	Incineration (plastics & PWB not re-used/recycled)	3,69	**0,00**	0,00	**0,00**	0,00	**54,83**	0,00	**0,28**	0,55	**0,01**	0,00	**0,99**	**0,00**	4,65	**0,31**	17,80
233	Plastics: Re-use & Recycling ("cost"-side)	0,03	**0,00**	0,00	**0,00**	0,00	**0,00**	0,01	**0,00**	0,01	**0,00**	0,00	**0,01**	**0,00**	0,13	**0,00**	0,00
	Re-use, Recycling Benefit	4,24	**1,90**	0,13	**1,71**	0,43	**2,13**	5,52	**0,28**	1,57	**0,02**	0,02	**0,24**	**0,20**	**0,08**	**1,08**	15,66
234	Plastics: Re-use, Closed Loop Recycling (please edit%	0,02	**0,00**	0,02	**0,00**	0,01	**0,00**	0,01	**0,00**	0,00	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,05
235	Plastics: Materials Recycling (please edit% only)	0,19	**0,01**	0,10	**0,01**	0,08	**0,01**	0,05	**0,00**	0,01	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,32
236	Plastics: Thermal Recycling (please edit% only)	1,48	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00	**0,11**	0,14	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,00
237	Electronics: PWB Easy to Disassemble ? (Click&select)	2,54	**1,88**	0,01	**1,70**	0,34	**2,12**	5,46	**0,17**	1,42	**0,02**	0,02	**0,24**	**0,20**	0,07	**1,08**	15,29
238	Metals & TV Glass & Misc. (95% Recycling)	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	**-0,17**	-1,90	-0,13	-1,71	-0,43	52,70	0,67	0,02	-0,97	-0,01	0,02	0,86	-0,20	5,15	-0,74	3,78

Table 5A1- 2 – Detailed environmental assessment results for 'DECT phone EPS' base-case

MATERIALS EXTRACTION & PRODUCTION

	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	Housing	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
2	Upper and bottom case	4,21	0,53	1,37	0,50	4,10	0,36	6,36	0,19	0,92	0,00	0,00	0,00	0,01	0,24	0,01	18,14
6	Electronic assembly	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
7	PWB	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
8	Big caps & coils (THT)	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	Coils + transformers	88,16	0,00	0,00	7,97	12,65	4,51	138,12	4,98	32,62	0,03	0,50	1,76	47,07	8,19	17,07	1,64
13	Slots / Ext. ports	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
17	IC's	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
23	SMD /LED's average	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
34	Miscellaneous	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
37	Solder	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
38	Cables	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
39	Copper wire	2,91	0,00	0,00	0,00	0,00	0,01	500,30	0,16	7,30	0,00	0,09	1,38	0,13	0,07	2,35	3,86
40	PVC	0,28	0,06	0,11	0,06	0,31	0,03	0,34	0,01	0,07	0,00	0,00	0,00	0,00	0,01	0,01	1,57
41	Plug	0,94	0,30	0,00	0,37	1,28	0,09	1,54	0,05	0,92	0,00	0,01	0,19	0,01	0,06	0,16	32,35
43	Packaging	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
44	Cardboard	0,56	0,04	0,32	0,14	0,00	0,00	1,05	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	1,72
45	Master carton	1,60	0,24	1,08	3,05	0,00	0,01	2,70	0,02	0,20	0,01	0,00	0,00	0,00	0,07	0,00	211,54
	TOTAL	98,65	1,17	2,88	12,09	18,34	5,00	650,40	5,43	42,05	0,04	0,60	3,33	47,23	8,65	19,61	270,82

MANUFACTURING																	
201	OEM Plastics Manufacturing (fixed)	1,67	1,01	0,06	0,02	0,48	0,00	5,25	0,09	0,40	0,00	0,00	0,00	0,00	0,06	0,00	0,98
205	PWB Manufacturing (fixed)	30,19	0,75	1,12	2,77	8,40	0,99	25,10	2,00	11,52	0,73	0,02	0,21	0,61	3,53	0,10	166,67
	TOTAL	31,87	1,76	1,18	2,78	8,88	0,99	30,34	2,10	11,92	0,73	0,02	0,21	0,61	3,60	0,10	167,64
DISTRIBUTION																	
		51,50	0,00	0,00	0,00	0,00	1,02	51,36	4,52	12,00	0,05	0,29	2,62	2,62	0,26	0,08	1,36
208	Is it an ICT or Consumer Electronics prod	1,48	0,00	0,01	0,00	0,00	0,01	0,66	0,12	0,41	0,02	0,00	0,03	0,02	0,45	0,00	0,02
		0,25	0,00	0,00	0,00	0,00	0,00	0,16	0,01	0,04	0,00	0,00	0,01	0,00	0,11	0,00	0,00
210	Volume of packaged final product in m3	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
		0,03	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	53,26	0,00	0,01	0,00	0,00	1,04	52,21	4,66	12,45	0,07	0,30	2,66	2,64	0,82	0,08	1,38
USE PHASE																	
		333,71	333,71	0,00	22,25	889,88	7,69	386,91	14,56	85,93	0,13	2,19	5,73	0,66	1,84	2,15	10,26
	TOTAL over Product Life	333,71	333,71	0,00	22,25	889,88	7,69	386,91	14,56	85,93	0,13	2,19	5,73	0,66	1,84	2,15	10,26
	Maintenance, Repairs, Service	1,31	0,03	0,04	0,15	0,27	0,06	6,81	0,08	0,54	0,01	0,01	0,04	0,48	0,12	0,20	4,38
225	No. of km over Product-Life	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
226	Spare parts (fixed, 1% of product material	1,31	0,03	0,04	0,15	0,27	0,06	6,81	0,08	0,54	0,01	0,01	0,04	0,48	0,12	0,20	4,38
	TOTAL	335,01	334	0	22	890	8	394	15	86	0	2	6	1	2	2	15
DISPOSAL/RECYCLING																	
	Disposal: Environmental Costs perkg final	11,65	0,00	0,00	0,00	0,00	154,40	22,14	0,87	1,73	0,03	0,16	3,15	0,00	14,81	0,98	55,97
231	Landfill (fraction products not recovered)	1,23	0,00	0,00	0,00	0,00	0,00	22,13	0,09	0,18	0,01	0,15	0,36	0,00	1,61	0,10	5,86
232	Incineration (plastics & PWB not re-used/r	10,39	0,00	0,00	0,00	0,00	154,40	0,00	0,77	1,54	0,02	0,00	2,78	0,00	13,08	0,88	50,12
233	Plastics: Re-use & Recycling ("cost"-side)	0,03	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,01	0,00	0,12	0,00	0,00
	Re-use, Recycling Benefit	21,16	13,63	0,19	12,31	2,57	15,34	39,53	1,41	10,53	0,16	0,15	1,73	1,42	0,53	7,83	110,85
234	Plastics: Re-use, Closed Loop Recycling (	0,02	0,00	0,02	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05
235	Plastics: Materials Recycling (please edit%	0,18	0,01	0,10	0,01	0,07	0,01	0,05	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,30
236	Plastics: Thermal Recycling (please edit%	2,59	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00
237	Electronics: PWB Easy to Disassemble ? ((	18,36	13,62	0,07	12,30	2,48	15,33	39,47	1,21	10,28	0,15	0,15	1,73	1,42	0,53	7,83	110,50
238	Metals & TV Glass & Misc. (95% Recycling)	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	-9,51	-13,63	-0,19	-12,31	-2,57	139,06	-17,39	-0,54	-8,80	-0,13	0,01	1,42	-1,42	14,28	-6,85	-54,88

Table 5A1- 3 – Detailed environmental assessment results for 'Standard battery charger' base-case

MATERIALS EXTRACTION & PRODUCTION

	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	Housing	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
2	Upper Case	3,39	0,43	1,10	0,41	3,31	0,29	5,12	0,16	0,74	0,00	0,00	0,00	0,01	0,19	0,00	14,62
3	Lower case	3,39	0,43	1,10	0,41	3,31	0,29	5,12	0,16	0,74	0,00	0,00	0,00	0,01	0,19	0,00	14,62
4	metal mountings	0,14	0,00	0,00	0,00	0,00	0,00	24,76	0,01	0,36	0,00	0,00	0,07	0,01	0,00	0,12	0,19
5	Electronic assembly	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
6	PWB (single sided)	2,01	1,08	0,06	1,22	0,55	12,39	18,77	0,08	1,53	0,02	0,02	0,26	0,03	0,04	0,11	26,36
8	Capacitors (electrolytic)	0,08	0,00	0,00	0,01	0,01	0,00	0,12	0,00	0,03	0,00	0,00	0,00	0,04	0,01	0,01	0,00
9	Capacitor (film)	0,09	0,00	0,00	0,01	0,01	0,00	0,14	0,00	0,03	0,00	0,00	0,00	0,05	0,01	0,02	0,00
10	Coils + transformers	47,14	0,00	0,00	4,26	6,77	2,41	73,87	2,67	17,44	0,02	0,27	0,94	25,17	4,38	9,13	0,88
12	Slots / Ext. ports	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
13	Slot 230V	1,07	0,34	0,00	0,43	1,46	0,10	1,75	0,06	1,05	0,00	0,01	0,22	0,01	0,07	0,18	36,88
14	IC's	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
15	IC (THT)	0,44	0,34	0,00	0,31	0,05	0,32	0,87	0,03	0,41	0,00	0,00	0,09	0,00	0,01	0,00	2,15
18	SMD /LED's average	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	SMD Capacitors	0,07	0,07	0,00	0,02	0,00	0,00	0,07	0,00	0,04	0,00	0,00	0,01	0,00	0,00	0,00	0,05
20	SMD resistors	0,07	0,07	0,00	0,02	0,00	0,00	0,07	0,00	0,04	0,00	0,00	0,01	0,00	0,00	0,00	0,05
21	SMD diodes	0,13	0,10	0,00	0,09	0,02	0,10	0,26	0,01	0,12	0,00	0,00	0,03	0,00	0,00	0,00	0,64
22	SMD transistors	0,15	0,12	0,00	0,11	0,02	0,11	0,31	0,01	0,14	0,00	0,00	0,03	0,00	0,00	0,00	0,75
23	Miscellaneous	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
24	THT resistors (1)	0,59	0,58	0,00	0,19	0,00	0,03	0,57	0,03	0,32	0,00	0,00	0,08	0,00	0,01	0,00	0,44
26	THT Diodes	0,44	0,34	0,00	0,31	0,05	0,32	0,87	0,03	0,41	0,00	0,00	0,09	0,00	0,01	0,00	2,15
27	THT Fuse	0,15	0,00	0,00	0,01	0,02	0,01	0,24	0,01	0,06	0,00	0,00	0,00	0,08	0,01	0,03	0,00
28	THT LED	1,75	1,35	0,01	1,22	0,21	1,29	3,50	0,12	1,63	0,00	0,02	0,37	0,01	0,05	0,02	8,59
30	switch AA/AAA	0,13	0,04	0,00	0,05	0,18	0,01	0,22	0,01	0,13	0,00	0,00	0,03	0,00	0,01	0,02	4,53
31	Solder	0,70	0,58	0,00	0,21	0,00	0,01	0,68	0,03	0,19	0,00	0,00	0,01	0,01	0,00	0,00	0,02
33	Cables	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
34	Copper wire	2,65	0,00	0,00	0,00	0,00	0,01	455,27	0,14	6,65	0,00	0,09	1,25	0,12	0,06	2,14	3,52
43	Miscellaneous	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
44	Adhesive (plastic tape, yellow glue)	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
45	Spacer (plastic cover)	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
46	Screws	0,02	0,00	0,00	0,00	0,00	0,00	0,86	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,03
47	El Metal	5,47	0,85	0,36	6,67	0,74	0,00	88,10	0,55	4,94	0,01	0,68	13,07	0,00	0,70	7,61	205,09
48	Eyelet and ring	0,00	0,00	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
49	Fibre paper	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	0,26
50	Intern Wire	0,57	0,00	0,00	0,00	0,00	0,00	98,06	0,03	1,43	0,00	0,02	0,27	0,03	0,01	0,46	0,76
	TOTAL	70,65	6,71	2,63	15,95	16,69	17,71	779,68	4,14	38,43	0,05	1,14	16,84	25,57	5,80	19,87	322,59

	MANUFACTURING																
201	OEM Plastics Manufacturing (fixed)	2,51	1,51	0,09	0,02	0,71	0,00	7,86	0,14	0,60	0,00	0,00	0,00	0,00	0,09	0,00	1,47
202	Foundries Fe/Cu/Zn (fixed)	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)	1,34	0,81	0,05	0,01	0,38	0,00	4,20	0,07	0,32	0,00	0,00	0,00	0,00	0,05	0,00	0,53
205	PWB Manufacturing (fixed)	18,07	0,45	0,67	1,66	5,03	0,59	15,02	1,20	6,89	0,44	0,01	0,12	0,36	2,11	0,06	99,73
206	Other materials (Manufacturing already in	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	0,27	0,11	0,00	0,00	0,00	0,00	3,99	0,02	0,08	0,00	0,24	0,56	0,00	0,01	0,00	0,01
	TOTAL	22,18	2,88	0,80	1,69	6,12	0,60	31,07	1,43	7,89	0,44	0,25	0,68	0,36	2,27	0,06	101,73
	DISTRIBUTION																
		51,50	0,00	0,00	0,00	0,00	1,02	51,36	4,52	12,00	0,05	0,29	2,62	2,62	0,26	0,08	1,36
208	Is it an ICT or Consumer Electronics prod	1,48	0,00	0,01	0,00	0,00	0,01	0,66	0,12	0,41	0,02	0,00	0,03	0,02	0,45	0,00	0,02
209	Is it an installed appliance (e.g. boiler)?	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
		0,25	0,00	0,00	0,00	0,00	0,00	0,16	0,01	0,04	0,00	0,00	0,01	0,00	0,11	0,00	0,00
210	Volume of packaged final product in m3	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
		0,03	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	53,26	0,00	0,01	0,00	0,00	1,04	52,21	4,66	12,45	0,07	0,30	2,66	2,64	0,82	0,08	1,38
	USE PHASE																
		252,45	252,45	0,00	16,83	673,21	5,82	292,70	11,02	65,01	0,10	1,65	4,33	0,50	1,39	1,63	7,76
211	Product Life in years																
	Electricity																
212	On-mode: Consumption per hour, cycle, setting, etc.																
213	On-mode: No. Of hours, cycles, settings, etc. / year																
214	Standby-mode: Consumption per hour																
215	Standby-mode: No. Of hours / year																
216	Off-mode: Consumption per hour																
217	Off-mode: No. Of hours / year																
	TOTAL over Product Life	252,45	252,45	0,00	16,83	673,21	5,82	292,70	11,02	65,01	0,10	1,65	4,33	0,50	1,39	1,63	7,76
226	Spare parts (fixed, 1% of product material	0,93	0,10	0,03	0,18	0,23	0,18	8,11	0,06	0,46	0,00	0,01	0,18	0,26	0,08	0,20	4,24
	TOTAL	253,38	253	0	17	673	6	301	11	65	0	2	5	1	1	2	12
	DISPOSAL/RECYCLING																
	Disposal: Environmental Costs perkg final	9,59	0,00	0,00	0,00	0,00	125,57	19,81	0,72	1,43	0,02	0,14	2,59	0,00	12,26	0,80	46,00
231	Landfill (fraction products not recovered)	1,10	0,00	0,00	0,00	0,00	0,00	19,79	0,08	0,16	0,00	0,14	0,32	0,00	1,44	0,09	5,24
232	Incineration (plastics & PWB not re-used/r	8,45	0,00	0,00	0,00	0,00	125,57	0,00	0,63	1,26	0,02	0,00	2,26	0,00	10,64	0,71	40,76
233	Plastics: Re-use & Recycling ("cost"-side)	0,04	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,01	0,00	0,00	0,01	0,00	0,19	0,00	0,00
	Re-use, Recycling Benefit	13,67	8,17	0,21	7,38	1,61	9,19	23,71	0,91	6,39	0,09	0,09	1,03	0,85	0,32	4,69	66,65
234	Plastics: Re-use, Closed Loop Recycling (	0,03	0,00	0,02	0,00	0,02	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,08
235	Plastics: Materials Recycling (please edit%	0,28	0,02	0,15	0,01	0,11	0,01	0,08	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,45
236	Plastics: Thermal Recycling (please edit%	2,37	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
237	Electronics: PWB Easy to Disassemble ? (	10,99	8,15	0,04	7,36	1,49	9,17	23,62	0,72	6,15	0,09	0,09	1,03	0,85	0,31	4,69	66,12
238	Metals & TV Glass & Misc. (95% Recycling)	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	-4,07	-8,17	-0,21	-7,38	-1,61	116,38	-3,90	-0,19	-4,96	-0,07	0,05	1,56	-0,85	11,94	-3,88	-20,65

Table 5A1- 4 – Detailed environmental assessment results for 'Printer EPS' base-case

MATERIALS EXTRACTION & PRODUCTION

	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	Housing	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
2	Upper and lower Case	6,00	0,76	1,95	0,72	5,85	0,51	9,07	0,28	1,31	0,00	0,00	0,00	0,02	0,34	0,01	25,88
3	Screws	0,08	0,00	0,00	0,00	0,00	0,00	1,57	0,00	0,03	0,00	0,00	0,00	0,04	0,01	0,01	0,00
4	Screws	0,02	0,00	0,00	0,00	0,00	0,00	0,84	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,03
5	Electronic assembly	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
6	**PWB (single sided)**	3,88	2,08	0,12	2,35	1,06	23,94	36,27	0,16	2,95	0,03	0,04	0,50	0,05	0,07	0,20	50,93
7	**Big caps & coils (THT)**	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
8	Capacitors (electrolytic)	4,58	0,00	0,00	0,41	0,66	0,23	7,17	0,26	1,69	0,00	0,03	0,09	2,44	0,43	0,89	0,09
9	Capacitor (film)	0,86	0,00	0,00	0,08	0,12	0,04	1,35	0,05	0,32	0,00	0,00	0,02	0,46	0,08	0,17	0,02
10	Coils + transformers	12,78	0,00	0,00	1,16	1,83	0,65	20,02	0,72	4,73	0,00	0,07	0,26	6,82	1,19	2,47	0,24
11	other big caps and coils	0,38	0,00	0,00	0,03	0,06	0,02	0,60	0,02	0,14	0,00	0,00	0,01	0,20	0,04	0,07	0,01
13	Capacitor (ceramic)	0,77	0,00	0,00	0,07	0,11	0,04	1,21	0,04	0,29	0,00	0,00	0,02	0,41	0,07	0,15	0,01
14	**Slots / Ext. ports**	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
15	slot 230V	1,59	0,50	0,00	0,63	2,17	0,15	2,61	0,09	1,57	0,00	0,01	0,32	0,02	0,11	0,27	54,93
16	**IC's**	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
18	ICs	1,23	0,95	0,00	0,86	0,15	0,91	2,47	0,08	1,15	0,00	0,01	0,26	0,00	0,03	0,01	6,06
19	**SMD / THT**	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	SMD Capacitors	0,34	0,33	0,00	0,10	0,00	0,01	0,32	0,02	0,18	0,00	0,00	0,05	0,00	0,01	0,00	0,25
21	SMD resistors	0,38	0,37	0,00	0,12	0,00	0,02	0,36	0,02	0,20	0,00	0,00	0,05	0,00	0,01	0,00	0,28
22	diodes	2,22	1,71	0,01	1,55	0,26	1,63	4,43	0,15	2,07	0,00	0,02	0,47	0,01	0,06	0,02	10,90
23	transistors	0,99	0,76	0,00	0,69	0,12	0,73	1,98	0,07	0,92	0,00	0,01	0,21	0,00	0,03	0,01	4,87
24	SMD miscelleneous	2,52	2,45	0,00	0,79	0,00	0,11	2,41	0,14	1,38	0,01	0,01	0,36	0,00	0,04	0,01	1,87
25	**Miscellaneous**	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
26	THT resistors	3,37	3,28	0,00	1,05	0,00	0,15	3,21	0,19	1,84	0,01	0,02	0,48	0,01	0,06	0,02	2,49
29	THT Fuse	0,42	0,00	0,00	0,04	0,06	0,02	0,66	0,02	0,16	0,00	0,00	0,01	0,22	0,04	0,08	0,01
30	THT ferrit	0,01	0,00	0,00	0,01	0,00	0,00	0,44	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,01
31	THT bridge, jumper	0,02	0,00	0,00	0,00	0,00	0,00	2,51	0,00	0,04	0,00	0,00	0,01	0,00	0,00	0,00	0,02
32	THT plug	0,12	0,02	0,05	0,02	0,13	0,01	0,15	0,00	0,03	0,00	0,00	0,00	0,00	0,01	0,01	0,68
33	Aluminum Heat sink	0,69	0,00	0,00	0,00	0,00	0,00	14,13	0,04	0,24	0,00	0,02	0,01	0,35	0,06	0,13	0,02
35	**Solder**	0,37	0,31	0,00	0,11	0,00	0,01	0,36	0,02	0,10	0,00	0,00	0,01	0,00	0,00	0,00	0,01
36	Cables	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
37	Copper wire	1,72	0,00	0,00	0,00	0,00	0,00	296,18	0,09	4,32	0,00	0,06	0,81	0,08	0,04	1,39	2,29
38	PVC	0,84	0,16	0,34	0,16	0,92	0,07	0,99	0,03	0,22	0,00	0,00	0,00	0,00	0,04	0,04	4,65
39	Plug	0,81	0,26	0,00	0,32	1,11	0,07	1,33	0,04	0,80	0,00	0,01	0,16	0,01	0,06	0,14	28,01
42	Miscellaneous	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
43	adhesive	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
44	rubber, gum	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
45	stealslide	0,02	0,00	0,00	0,00	0,00	0,00	1,01	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,04
46	fusecover	0,01	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,04
47	sheat assembly	0,05	0,00	0,00	0,00	0,00	0,00	0,98	0,00	0,02	0,00	0,00	0,00	0,02	0,00	0,01	0,00
48	glue	0,11	0,01	0,03	0,01	0,10	0,01	0,16	0,00	0,02	0,00	0,00	0,00	0,00	0,01	0,00	0,45
51	Packaging	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
52	foil	0,16	0,03	0,11	0,01	0,09	0,01	0,09	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,06
	TOTAL	47,33	13,98	2,62	11,30	14,81	29,37	414,88	2,55	26,75	0,06	0,36	4,11	11,18	2,83	6,13	195,12

	MANUFACTURING																
201	OEM Plastics Manufacturing (fixed)	2,92	1,76	0,10	0,03	0,83	0,00	9,14	0,16	0,70	0,00	0,00	0,00	0,00	0,11	0,00	1,71
203	Foundries Al/Mg (fixed)	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)	0,08	0,05	0,00	0,00	0,02	0,00	0,26	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,03
205	PWB Manufacturing (fixed)	10,55	0,26	0,39	0,97	2,94	0,35	8,77	0,70	4,02	0,25	0,01	0,07	0,21	1,23	0,04	58,22
207	Sheetmetal Scrap (Please adjust percentag	0,02	0,01	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,01	0,03	0,00	0,00	0,00	0,00
	TOTAL	13,57	2,08	0,50	0,99	3,79	0,35	18,42	0,87	4,75	0,26	0,02	0,11	0,21	1,35	0,04	59,96
	DISTRIBUTION																
		51,50	0,00	0,00	0,00	0,00	1,02	51,36	4,52	12,00	0,05	0,29	2,62	2,62	0,26	0,08	1,36
208	Is it an ICT or Consumer Electronics produ	0,89	0,00	0,01	0,00	0,00	0,01	0,40	0,07	0,24	0,01	0,00	0,02	0,01	0,27	0,00	0,01
209	Is it an installed appliance (e.g. boiler)?	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
		0,15	0,00	0,00	0,00	0,00	0,00	0,10	0,01	0,03	0,00	0,00	0,00	0,00	0,06	0,00	0,00
210	Volume of packaged final product in m3	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
		0,02	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	52,56	0,00	0,01	0,00	0,00	1,03	51,87	4,60	12,27	0,06	0,29	2,64	2,63	0,59	0,08	1,38
	USE PHASE																
		543,26	543,26	0,00	36,22	1448,69	12,52	629,88	23,71	139,89	0,20	3,56	9,32	1,07	2,99	3,50	16,70
	TOTAL over Product Life	543,26	543,26	0,00	36,22	1448,69	12,52	629,88	23,71	139,89	0,20	3,56	9,32	1,07	2,99	3,50	16,70
	Maintenance, Repairs, Service	0,61	0,16	0,03	0,12	0,19	0,30	4,33	0,03	0,31	0,00	0,00	0,04	0,11	0,04	0,06	2,55
225	No. of km over Product-Life	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
226	Spare parts (fixed, 1% of product materials	0,61	0,16	0,03	0,12	0,19	0,30	4,33	0,03	0,31	0,00	0,00	0,04	0,11	0,04	0,06	2,55
	TOTAL	543,87	543	0	36	1449	13	634	24	140	0	4	9	1	3	4	19
	DISPOSAL/RECYCLING																
	Disposal: Environmental Costs perkg final	7,75	0,00	0,00	0,00	0,00	105,35	11,01	0,58	1,16	0,02	0,08	2,09	0,00	9,94	0,65	37,10
231	Landfill (fraction products not recovered) i	0,61	0,00	0,00	0,00	0,00	0,00	10,99	0,05	0,09	0,00	0,08	0,18	0,00	0,80	0,05	2,91
232	Incineration (plastics & PWB not re-used/re	7,09	0,00	0,00	0,00	0,00	105,35	0,00	0,53	1,05	0,01	0,00	1,90	0,00	8,93	0,60	34,19
233	Plastics: Re-use & Recycling ("cost"-side)	0,05	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,01	0,00	0,00	0,01	0,00	0,22	0,00	0,00
	Re-use, Recycling Benefit	9,13	4,78	0,22	4,31	1,02	5,37	13,89	0,61	3,83	0,06	0,05	0,60	0,50	0,19	2,74	39,22
234	Plastics: Re-use, Closed Loop Recycling (pl	0,04	0,00	0,03	0,00	0,02	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09
235	Plastics: Materials Recycling (please edit%	0,32	0,02	0,17	0,02	0,13	0,01	0,09	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,53
236	Plastics: Thermal Recycling (please edit% c	2,36	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
237	Electronics: PWB Easy to Disassemble ? (Cl	6,42	4,76	0,02	4,30	0,87	5,36	13,79	0,42	3,59	0,05	0,05	0,60	0,50	0,18	2,74	38,60
238	Metals & TV Glass & Misc. (95% Recycling)	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	-1,38	-4,78	-0,22	-4,31	-1,02	99,97	-2,88	-0,03	-2,67	-0,04	0,03	1,48	-0,50	9,75	-2,09	-2,11

Table 5A1- 5 – Detailed environmental assessment results for ‘Laptop EPS without PFC’ base-case

MATERIALS EXTRACTION & PRODUCTION

	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	Housing	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
2	Upper Case + Lower Case	5,59	0,71	1,82	0,67	5,46	0,48	8,45	0,26	1,22	0,00	0,00	0,00	0,02	0,32	0,01	24,13
5	Electronic assembly	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
6	PWB (single sided)	2,03	1,09	0,06	1,23	0,55	12,50	18,93	0,08	1,54	0,02	0,02	0,26	0,03	0,04	0,11	26,59
8	Capacitors (electrolytic)	6,93	0,00	0,00	0,63	0,99	0,35	10,86	0,39	2,56	0,00	0,04	0,14	3,70	0,64	1,34	0,13
9	Capacitor (film) +ceramic	1,51	0,00	0,00	0,14	0,22	0,08	2,36	0,09	0,56	0,00	0,01	0,03	0,81	0,14	0,29	0,03
10	Coils + transformers	16,88	0,00	0,00	1,53	2,42	0,86	26,45	0,95	6,25	0,01	0,10	0,34	9,01	1,57	3,27	0,31
12	**Slots / Ext. ports**	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
13	Slot 230V	0,98	0,31	0,00	0,39	1,34	0,09	1,61	0,05	0,97	0,00	0,01	0,20	0,01	0,07	0,17	33,93
14	**IC's**	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
15	IC (THT)+SMD	0,44	0,34	0,00	0,31	0,05	0,33	0,88	0,03	0,41	0,00	0,00	0,09	0,00	0,01	0,00	2,17
18	**SMD /LED's average**	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	SMD Capacitors	0,31	0,30	0,00	0,10	0,00	0,01	0,30	0,02	0,17	0,00	0,00	0,04	0,00	0,01	0,00	0,23
20	SMD resistors +trasnistor	0,79	0,77	0,00	0,25	0,00	0,03	0,76	0,04	0,43	0,00	0,00	0,11	0,00	0,01	0,00	0,59
21	SMD diodes	0,28	0,27	0,00	0,09	0,00	0,01	0,26	0,02	0,15	0,00	0,00	0,04	0,00	0,00	0,00	0,20
23	**Miscellaneous**	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
24	THT resistors + transitors + Diodes +rectifier	17,65	17,15	0,00	5,50	0,00	0,78	16,83	0,99	9,63	0,04	0,09	2,51	0,03	0,30	0,09	13,05
27	THT Fuse	0,86	0,84	0,00	0,27	0,00	0,04	0,82	0,05	0,47	0,00	0,00	0,12	0,00	0,01	0,00	0,64
28	THT ferrit	0,79	0,76	0,00	0,25	0,00	0,03	0,75	0,04	0,43	0,00	0,00	0,11	0,00	0,01	0,00	0,58
29	THT bridge, jumper	0,01	0,00	0,00	0,00	0,00	0,00	1,80	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,01	0,01
31	Solder	0,20	0,16	0,00	0,06	0,00	0,00	0,19	0,01	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,01
33	**Cables**	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
34	Copper wire	3,98	0,00	0,00	0,00	0,00	0,01	682,91	0,21	9,97	0,00	0,13	1,88	0,18	0,10	3,21	5,27
35	PVC	1,93	0,38	0,78	0,38	2,12	0,17	2,29	0,07	0,51	0,00	0,00	0,00	0,00	0,10	0,10	10,71
36	Plug THT	0,60	0,19	0,00	0,24	0,82	0,05	0,99	0,03	0,59	0,00	0,00	0,12	0,01	0,04	0,10	20,80
37	Plug low voltage	1,16	0,37	0,00	0,46	1,58	0,11	1,90	0,06	1,14	0,00	0,01	0,24	0,01	0,08	0,20	40,05
43	Miscellaneous	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
44	Adhesive (Silicone)+Spacer (elastomer...)+tape	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
46	Screws + metal mountings	0,05	0,00	0,00	0,00	0,00	0,00	2,61	0,00	0,01	0,00	0,04	0,01	0,00	0,00	0,01	0,10
47	Aluminum Heat sink	4,38	0,00	0,00	0,00	0,00	0,00	89,12	0,24	1,53	0,00	0,11	0,08	2,19	0,38	0,80	0,11
48	heat sink with cooper	1,16	0,00	0,00	0,00	0,00	0,00	182,72	0,06	1,43	0,00	0,23	0,75	0,12	0,03	0,86	1,41
49	Shield (plastic)	0,15	0,01	0,11	0,01	0,08	0,01	0,06	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,33
50	Intern Wire	0,05	0,00	0,00	0,00	0,00	0,00	8,10	0,00	0,12	0,00	0,00	0,02	0,00	0,00	0,04	0,06
51	Intern Wire	0,05	0,01	0,02	0,01	0,05	0,00	0,05	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,25
	TOTAL	68,74	23,67	2,79	12,49	15,68	15,96	1062,02	3,72	40,20	0,08	0,81	7,11	16,13	3,89	10,61	181,71

	MANUFACTURING																
201	OEM Plastics Manufacturing (fixed)	3,46	2,09	0,12	0,03	0,98	0,00	10,86	0,19	0,83	0,00	0,00	0,00	0,00	0,13	0,00	2,03
204	Sheetmetal Manufacturing (fixed)	0,71	0,43	0,02	0,01	0,20	0,00	2,23	0,04	0,17	0,00	0,00	0,00	0,00	0,03	0,00	0,28
205	PWB Manufacturing (fixed)	12,30	0,31	0,46	1,13	3,42	0,40	10,22	0,82	4,69	0,30	0,01	0,08	0,25	1,44	0,04	67,88
206	Other materials (Manufacturing already included)	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 percentage only)	0,14	0,06	0,00	0,00	0,00	0,00	2,12	0,01	0,04	0,00	0,13	0,30	0,00	0,01	0,00	0,00
	TOTAL	16,62	2,88	0,60	1,17	4,61	0,40	25,43	1,06	5,73	0,30	0,14	0,38	0,25	1,60	0,04	70,19
	DISTRIBUTION																
		51,50	0,00	0,00	0,00	0,00	1,02	51,36	4,52	12,00	0,05	0,29	2,62	2,62	0,26	0,08	1,36
208	Is it an ICT or Consumer Electronics product <15 kg ?	1,04	0,00	0,01	0,00	0,00	0,01	0,46	0,08	0,28	0,01	0,00	0,02	0,01	0,32	0,00	0,01
209	Is it an installed appliance (e.g. boiler)?	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
		0,17	0,00	0,00	0,00	0,00	0,00	0,11	0,01	0,03	0,00	0,00	0,01	0,00	0,08	0,00	0,00
210	Volume of packaged final product in m3	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
		0,02	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	52,73	0,00	0,01	0,00	0,00	1,03	51,95	4,62	12,32	0,07	0,29	2,65	2,64	0,65	0,08	1,38
	USE PHASE																
		2305,63	2305,63	0,00	153,71	6148,36	53,13	2673,25	100,62	593,70	0,87	15,11	39,56	4,54	12,68	14,87	70,89
	Maintenance, Repairs, Service	0,85	0,27	0,03	0,14	0,20	0,16	10,87	0,05	0,46	0,00	0,01	0,07	0,16	0,05	0,11	2,52
226	Spare parts (fixed, 1% of product materials & manuf.)	0,85	0,27	0,03	0,14	0,20	0,16	10,87	0,05	0,46	0,00	0,01	0,07	0,16	0,05	0,11	2,52
	TOTAL	2.306,49	2306	0	154	6149	53	2684	101	594	1	15	40	5	13	15	73
	DISPOSAL/RECYCLING																
	Disposal: Environmental Costs perkg final product	9,34	0,00	0,00	0,00	0,00	124,20	16,58	0,70	1,39	0,02	0,12	2,52	0,00	11,98	0,78	44,69
231	Landfill (fraction products not recovered) in g en %	0,92	0,00	0,00	0,00	0,00	0,00	16,55	0,07	0,14	0,00	0,11	0,27	0,00	1,20	0,08	4,38
232	Incineration (plastics & PWB not re-used/recycled)	8,36	0,00	0,00	0,00	0,00	124,20	0,00	0,62	1,24	0,02	0,00	2,24	0,00	10,52	0,71	40,31
233	Plastics: Re-use & Recycling ("cost"-side)	0,06	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,02	0,00	0,00	0,01	0,00	0,26	0,00	0,00
	Re-use, Recycling Benefit	10,42	5,58	0,26	5,03	1,19	6,26	16,20	0,69	4,45	0,07	0,06	0,70	0,58	0,22	3,19	45,74
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	0,05	0,00	0,03	0,00	0,03	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10
235	Plastics: Materials Recycling (please edit% only)	0,38	0,03	0,20	0,02	0,15	0,02	0,11	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,63
236	Plastics: Thermal Recycling (please edit% only)	2,51	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00
237	Electronics: PWB Easy to Disassemble ? (Click&select)	7,48	5,55	0,03	5,01	1,01	6,24	16,08	0,49	4,19	0,06	0,06	0,70	0,58	0,21	3,19	45,01
238	Metals & TV Glass & Misc. (95% Recycling)	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	-1,08	-5,58	-0,26	-5,03	-1,19	117,93	0,38	0,01	-3,05	-0,04	0,06	1,81	-0,58	11,76	-2,41	-1,04

Table 5A1- 6 – Detailed environmental assessment results for 'Laptop EPS with PFC' base-case

MATERIALS EXTRACTION & PRODUCTION

	Product	Energy			Water		Waste		Emissions to Air							to Water	
nr	component	GER	electr	feedst	water (proces	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		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	**Housing**	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
2	case	8,53	**1,08**	2,77	**1,02**	8,32	**0,73**	12,89	**0,39**	1,86	**0,00**	0,00	**0,00**	**0,03**	0,49	**0,01**	36,79
3	metal mountings	0,19	**0,03**	0,01	**0,23**	0,03	**0,00**	3,07	**0,02**	0,17	**0,00**	0,02	**0,46**	**0,00**	0,02	**0,27**	7,15
4	**Electronic assembly**	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
5	PWB	3,71	**1,99**	0,11	**2,24**	1,01	**22,88**	34,65	**0,15**	2,82	**0,03**	0,04	**0,48**	**0,05**	0,07	**0,19**	48,66
6	Big caps & coils (THT)	55,34	**0,00**	0,00	**5,00**	7,94	**2,83**	86,72	**3,13**	20,48	**0,02**	0,31	**1,11**	**29,55**	5,14	**10,72**	1,03
7	Slots / Ext. ports	0,88	**0,28**	0,00	**0,35**	1,20	**0,08**	1,45	**0,05**	0,87	**0,00**	0,01	**0,18**	**0,01**	0,06	**0,15**	30,41
8	IC's	2,68	**2,07**	0,01	**1,88**	0,32	**1,98**	5,36	**0,18**	2,50	**0,00**	0,03	**0,57**	**0,01**	0,07	**0,03**	13,18
9	SMD /LED's average	4,24	**4,12**	0,00	**1,32**	0,00	**0,19**	4,04	**0,24**	2,31	**0,01**	0,02	**0,60**	**0,01**	0,07	**0,02**	3,14
10	Miscellaneous	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	THT Fuse	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
12	heat sink for coils	0,10	**0,00**	0,00	**0,00**	0,00	**0,00**	15,23	**0,01**	0,12	**0,00**	0,02	**0,06**	**0,01**	0,00	**0,07**	0,12
13	Solder	0,29	**0,24**	0,00	**0,09**	0,00	**0,01**	0,28	**0,01**	0,08	**0,00**	0,00	**0,00**	**0,00**	0,00	**0,00**	0,01
14	**Cables**	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
15	Copper wire	5,13	**0,00**	0,00	**0,00**	0,00	**0,01**	880,53	**0,27**	12,85	**0,00**	0,16	**2,42**	**0,24**	0,12	**4,14**	6,80
16	PVC	2,49	**0,49**	1,01	**0,48**	2,73	**0,22**	2,95	**0,10**	0,66	**0,00**	0,00	**0,00**	**0,00**	0,13	**0,12**	13,82
17	Plug	1,48	**0,47**	0,00	**0,59**	2,02	**0,14**	2,43	**0,08**	1,46	**0,00**	0,01	**0,30**	**0,02**	0,10	**0,25**	51,11
18	**Miscellaneous**	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	heat sink	1,51	**0,00**	0,00	**0,00**	0,00	**0,00**	237,21	**0,08**	1,85	**0,00**	0,30	**0,98**	**0,16**	0,04	**1,11**	1,83
20	spacer	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
21	heat sink 2	3,35	**0,00**	0,00	**0,00**	0,00	**0,00**	68,21	**0,18**	1,17	**0,00**	0,09	**0,06**	**1,68**	0,29	**0,61**	0,09
22	div. plastic sheets	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
23	lacing cord	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	**89,91**	**10,76**	3,92	**13,21**	23,57	**29,06**	1355,02	**4,88**	49,20	**0,06**	**1,02**	**7,22**	**31,75**	**6,63**	**17,70**	**214,12**

	MANUFACTURING																
201	OEM Plastics Manufacturing (fixed)	5,05	3,04	0,17	0,05	1,43	0,00	15,82	0,28	1,21	0,00	0,00	0,00	0,00	0,19	0,00	2,95
202	Foundries Fe/Cu/Zn (fixed)	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)	0,00	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)	0,79	0,47	0,03	0,01	0,22	0,00	2,46	0,04	0,19	0,00	0,00	0,00	0,00	0,03	0,00	0,31
205	PWB Manufacturing (fixed)	22,21	0,55	0,83	2,04	6,18	0,73	18,46	1,47	8,47	0,54	0,02	0,15	0,45	2,60	0,07	122,58
206	Other materials (Manufacturing already in	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	0,16	0,06	0,00	0,00	0,00	0,00	2,34	0,01	0,05	0,00	0,14	0,33	0,00	0,01	0,00	0,00
	TOTAL	28,20	4,13	1,03	2,09	7,84	0,73	39,08	1,81	9,91	0,54	0,16	0,48	0,45	2,82	0,07	125,85
	DISTRIBUTION																
		51,50	0,00	0,00	0,00	0,00	1,02	51,36	4,52	12,00	0,05	0,29	2,62	2,62	0,26	0,08	1,36
208	Is it an ICT or Consumer Electronics prod	1,45	0,00	0,01	0,00	0,00	0,01	0,65	0,11	0,40	0,02	0,00	0,03	0,02	0,44	0,00	0,02
209	Is it an installed appliance (e.g. boiler)?	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
		0,24	0,00	0,00	0,00	0,00	0,00	0,16	0,01	0,04	0,00	0,00	0,01	0,00	0,11	0,00	0,00
210	Volume of packaged final product in m3	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
		0,03	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	53,23	0,00	0,01	0,00	0,00	1,04	52,19	4,65	12,44	0,07	0,30	2,66	2,64	0,80	0,08	1,38
	USE PHASE																
		3068,04	3068,04	0,00	204,54	8181,45	70,70	3557,22	133,89	790,02	1,16	20,11	52,64	6,04	16,87	19,78	94,33
	TOTAL over Product Life	3068,04	3068,04	0,00	204,54	8181,45	70,70	3557,22	133,89	790,02	1,16	20,11	52,64	6,04	16,87	19,78	94,33
	Maintenance, Repairs, Service	1,18	0,15	0,05	0,15	0,31	0,30	13,94	0,07	0,59	0,01	0,01	0,08	0,32	0,09	0,18	3,40
225	No. of km over Product-Life	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
226	Spare parts (fixed, 1% of product material	1,18	0,15	0,05	0,15	0,31	0,30	13,94	0,07	0,59	0,01	0,01	0,08	0,32	0,09	0,18	3,40
	TOTAL	3.069,23	3068	0	205	8182	71	3571	134	791	1	20	53	6	17	20	98
	DISPOSAL/RECYCLING																
	Disposal: Environmental Costs perkg final	14,77	0,00	0,00	0,00	0,00	197,66	24,96	1,10	2,20	0,04	0,18	3,98	0,00	18,93	1,24	70,76
231	Landfill (fraction products not recovered)	1,39	0,00	0,00	0,00	0,00	0,00	24,92	0,10	0,20	0,01	0,17	0,41	0,00	1,81	0,12	6,60
232	Incineration (plastics & PWB not re-used/r	13,30	0,00	0,00	0,00	0,00	197,66	0,00	0,99	1,98	0,03	0,01	3,56	0,00	16,75	1,12	64,16
233	Plastics: Re-use & Recycling ("cost"-side)	0,08	0,00	0,00	0,00	0,00	0,00	0,04	0,01	0,02	0,00	0,00	0,02	0,00	0,37	0,00	0,00
	Re-use, Recycling Benefit	17,65	10,06	0,39	9,08	2,09	11,31	29,21	1,17	7,93	0,12	0,11	1,27	1,05	0,40	5,76	82,34
234	Plastics: Re-use, Closed Loop Recycling (|	0,07	0,01	0,05	0,00	0,04	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,15
235	Plastics: Materials Recycling (please edit%	0,55	0,04	0,29	0,03	0,22	0,02	0,16	0,01	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,92
236	Plastics: Thermal Recycling (please edit%	3,52	0,00	0,00	0,00	0,00	0,00	0,00	0,26	0,33	0,00	0,00	0,00	0,00	0,01	0,00	0,00
237	Electronics: PWB Easy to Disassemble ? ((	13,51	10,02	0,05	9,05	1,83	11,28	29,03	0,89	7,56	0,11	0,11	1,27	1,04	0,39	5,76	81,27
238	Metals & TV Glass & Misc. (95% Recycling)	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	-2,88	-10,06	-0,39	-9,08	-2,09	186,36	-4,25	-0,07	-5,72	-0,08	0,07	2,71	-1,05	18,53	-4,52	-11,58

ANNEX 5-2 – INPUTS FOR LCC AND EU-TOTALS

Below input data for the calculation of Life Cycle Cost and EU Totals is presented for the base-cases in the EcoReport format.

Data for product life, annual sales, EU stock are derived from the market analysis. The only relevant cost data for external power supplies is the product price (which refers to EPS sold as accessory for an end-application, not to a separately sold replacement part which comes at prices several times that of manufacturing costs), and the electricity rate (EU average). For standard battery chargers the cost of batteries is included as they can be considered as consumables.

The “overall improvement ratio stock vs. new, use phase” is estimated with 10% (equals a ratio of 1.1), taking into account the market trend to replace linear EPS by switched-mode ones and the improvements realised in switch-mode technology.

Table 5A2- 1 – Inputs for LCC and EU-Totals for Mobile phone EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	3	years
B	Annual sales	269	mln. Units/year
C	EU Stock	807,1	mln. Units
D	Product price	3,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	2,72	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 2 – Inputs for LCC and EU-Totals for DECT phone EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	6	years
B	Annual sales	30	mln. Units/year
C	EU Stock	150	mln. Units
D	Product price	3,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	5,08	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 3 – Inputs for LCC and EU-Totals for Digital camera EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	3	years
B	Annual sales	36	mln. Units/year
C	EU Stock	108,3	mln. Units
D	Product price	6,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	2,72	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 4 – Inputs for LCC and EU-Totals for Set-top box/Modem EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	3	years
B	Annual sales	22,9	mln. Units/year
C	EU Stock	68,7	mln. Units
D	Product price	6,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	2,72	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 5 – Inputs for LCC and EU-Totals for Personal care product EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	4	years
B	Annual sales	10	mln. Units/year
C	EU Stock	40	mln. Units
D	Product price	3,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	3,55	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 6 – Inputs for LCC and EU-Totals for Standard battery charger base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	5	years
B	Annual sales	20	mln. Units/year
C	EU Stock	100	mln. Units
D	Product price	15	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0.136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None	3	Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5.0%	%
N	Present Worth Factor (PWF) (calculated automatically)	4.33	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1.10	

In the entry 'I' above the price of "3" is entered[46], the unit actually has to be "Euro/battery" instead of "Euro/kg", the batteries being the "Auxiliary input 1".

Table 5A2- 7 – Inputs for LCC and EU-Totals for Power tool charger base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	5.5	years
B	Annual sales	14	mln. Units/year
C	EU Stock	77	mln. Units
D	Product price	19.5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0.136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5.0%	%
N	Present Worth Factor (PWF) (calculated automatically)	4.71	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1.10	

46 Average price of 4 AA cells is estimated at 12 euros (task 2)

Table 5A2- 8 – Inputs for LCC and EU-Totals for Printer EPS base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	4	years
B	Annual sales	30	mln. Units/year
C	EU Stock	120,8	mln. Units
D	Product price	12,5	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	3,55	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 9 – Inputs for LCC and EU-Totals for 'Halogen lighting transformer (magnetic)' base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	10	years
B	Annual sales	6	mln. Units/year
C	EU Stock	100	mln. Units
D	Product price	20	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	7,72	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 10 – Inputs for LCC and EU-Totals for ‘Halogen lighting transformer (electronic)’ base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	10	years
B	Annual sales	14	mln. Units/year
C	EU Stock	100	mln. Units
D	Product price	20	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	7,72	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 11 – Inputs for LCC and EU-Totals for Laptop EPS (without PFC) base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	5	years
B	Annual sales	16	mln. Units/year
C	EU Stock	80	mln. Units
D	Product price	30	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	4,33	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

Table 5A2- 12 – Inputs for LCC and EU-Totals for Laptop EPS (with PFC) base-case

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	5	years
B	Annual sales	4	mln. Units/year
C	EU Stock	20	mln. Units
D	Product price	30	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,136	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5,0%	%
N	Present Worth Factor (PWF) (calculated automatically)	4,33	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1,10	

6. TECHNICAL ANALYSIS OF BAT

This section presents the Task 6 of the lot 7 EuP preparatory study on Battery Chargers (BC) and External Power Supplies (EPS). Task 6 entails a description and technical analysis of Best Available Technologies (BAT) and Best Not yet Available Technologies (BNAT), either at product or component level.

BAT is a technology, leading to minimised environmental impacts, which is already available on the market or at least the technical feasibility has already been demonstrated (expected to be introduced at product level within 1-3 years). BNAT refers to technology, which has the potential to lead to further (environmental) performance improvements, but is still subject to research and development and is rather a future option / trend.

In addition to BAT and BNAT, which are technology options for improving the existing products, there are alternative products with increased environmental performance which have the potential of replacing current BC and EPS in the long run. These “best (not yet) available alternative products” will also be discussed in this section.

The assessment of the BAT and BNAT provides input for the identification of the improvement potential in Task 7. Intellectual property, technical feasibility, and availability on market in a strict sense are not judged here as the objective is to illustrate various technically available (or potentially available) options. However, the task 7 will take these issues into account when suggesting possible improvement options applicable to the lot 7 products.

The description of technologies presented here is based on ongoing research. New cutting edge technologies are highly guarded secrets and detailed public information is limited. Thus, the information presented here should be seen as a general overview of potential improvement options rather than a thorough technical analysis.

Note:

Task 6 is based on a literature search as well as contributions from stakeholders. All the registered Lot 7 stakeholders were invited to provide input to this task, and others were also welcome to contribute. Important BATs have been covered to the best of our knowledge.

Most of the technical data for this task has been provided directly by the manufacturers/designers or come from other published information. However, the efficiency or other performance levels claimed by them have not been verified independently.

6.1. STATE-OF-THE-ART ALREADY ON THE MARKET (PRODUCT LEVEL)

6.1.1 HIGH-EFFICIENCY EXTERNAL POWER SUPPLIES

Outstanding individual EPS, in terms of average active efficiency, are listed in Table 6-1 to give an overview of what is already available on the market in different output power ranges (this data is retrieved from the latest ENERGY STAR list[1]). However, this does not mean that all kind of power requirement specifications can be met with such highly efficient EPS.

Even in the power output range of 3.5-10 W, there are EPS achieving average efficiencies above 80% and in the output power below 3.5 W more than 65% average efficiency is achieved by several EPS. The best performing EPS achieve **efficiencies 10% and 6% higher than the assumed market average** (see Task 4 document) in the range up to 6 W and above 6 W respectively. Quite a few highly efficient EPS in the low power range have very low **no-load losses** (not exceeding **0.2 W)**, and some even below 0.1 W. In the high power range too, no-load losses below **0.5 W** are achieved by many EPS.

In general, a high innovation potential can be identified in the market: compared to the prior ENERGY STAR list of May 30, 2006, the recent list from October 29, 2006, includes a number of EPS much better than the best performing products of half a year ago.

Another key observation can be made that the "best in class" power supplies come from a variety of manufacturers. Actually the list in Table 6-1 comprises external power supplies from 16 different manufacturers.

1 Qualified Product (QP) List for ENERGY STAR® Ac-Dc Qualified External Power Supplies, List current as of October 29, 2006

Table 6-1 – Outstanding EPS in terms of average efficiency and no-load losses[2]

Company Name	Model	Nameplate DC Output Power (W)	No Load Input Power 230V @ 50Hz (W)	Average Active Efficiency 230V @ 50Hz (%)
FRIWO Power Solutions GmbH	1825266	1.5	0.181	58%
Salcomp (ShenZhen) Co. Ltd.	AC-3U	1.75	0.12	66%
Huizhou Skyfortune Electronics Co. Ltd. (HK)	S005CU0750025	1.875	0.16	65%
Huizhou Skyfortune Electronics Co. Ltd. (HK)	S002CU0900021	1.89	0.12	64%
Huizhou Skyfortune Electronics Co. Ltd. (HK)	S005CU0750030	2.25	0.17	66%
Leader Electronics, Inc.	MU03-F120020-A1 (15-1985)	2.4	0.13	68%
Dee Van Enterprise Co., Ltd. (TW)	DSC-31FL US 52050	2.6	0.2261	67%
Salcomp (ShenZhen) Co. Ltd.	AC-2E	2.65	0.09	64%
Salcomp (ShenZhen) Co. Ltd.	491XS	3.25	0.16	69%
Dong Yang E&P Inc.	TAD037	3.5	0.06	64%
H & T Corporation	TAD037	3.5	0.18	66%
Leader Electronics, Inc.	MU03-F120030-A1 (Goodmind)	3.6	0.129	72%
FRIWO Mobile Power GmbH	AC - 4E	4.45	0.19	72%
FRIWO Mobile Power GmbH	15.2287	4.56	0.2	73%
Dong Yang E&P Inc.	AA-M2	4.8	0.06	74%
CUI Inc	EPS060085	5	0.218	73%
Hitron Electronics Corporation	HEG06-S120050	6	0.156	81%
Tech-Power International Co.	PQLV206 XX ZA-LH	6.75	0.14	77%
FRIWO Power Solutions GmbH	1814905	7.2	0.16	76%
Dong Yang E&P Inc.	AA-E9	8.4	0.22	76%
Huizhou Skyfortune Electronics Co. Ltd.	S024EM0900100	9	0.145	79%
Total Power International	TPLG10-090110-1	9.9	0.1	86%
Hitron Electronics Corporation	HEG10-900110-1	9.9	0.15	88%
Huizhou Skyfortune Electronics Co. Ltd.	S024EM0900120	10.8	0.08	81%
Leader Electronics, Inc.	MV12-D120100-C5 (ASUS)	12	0.111	85%
Huizhou Skyfortune Electronics Co. Ltd.	S024EM0900150	13.5	0.11	81%
Jentec Technology Co., LTD.	AH1812-X (1A25)	15	0.3	80%
Delta Electronics Inc.	EADP-18FB B	18	0.233	83%
SIRTEC International Co. Ltd.	HPW-2024FG	20	0.43	86%
Asian Power Devices INC.	DA-24B12-FAA	24	0.16	85%
Asian Power Devices INC.	DA-36E24	36	0.548	87%
Asian Power Devices INC.	DA-42H24-AXX	42	0.317	89%
Hitron Electronics Corporation	HEG42-240200-7L	48	0.19	87%
Li Shin International Enterprise Corporation	0225C1950	50	0.386	88%
Delta Electronics Inc.	ADP-60NH B	60	0.39	89%
Li Shin International Enterprise Corporation	0335A1865	65	0.542	88%
Delta Electronics Inc.	ADP-80LB XX	80	0.42	88%
Li Shin International Enterprise Corporation	0220A1890	90	0.43	89%
Lite-On Technology Corporation	PA-1121-07XX	120	0.297	88%
Delta Electronics Inc.	ADP-120SB X	120	0.7267	90%
Huizhou Skyfortune Electronics Co. Ltd.	S150AQ2400620	148.8	0.168	89%
Delta Electronics Inc.	ADP-150GB X	150	0.7067	88%
Lite-On Technology Corporation	PA-1181-02AS	180	0.5	88%

Further, state-of-the art EPS products are identified, e.g. the prize winners of the efficiency challenge contest jointly organised by US EPA and CEC (California

2 Qualified Product (QP) List for ENERGY STAR® Ac-Dc Qualified External Power Supplies, List current as of October 29, 2006 (excerpt)

energy Commission). This being an international competition and products destined for the worldwide market, the winning products are of relevance for the European market as well.

EPS (low output power range) for DECT Phone

Designer	Power Integrations, Inc.
Product Name	EP-16-2.75 Using LNK501
Average Efficiency	69%
Application	DECT Phone
Output Power	2.75 W
Output Voltage	5.5 V
Output Current	500 mA

It is claimed that because of the high operational and standby efficiency of this EPS, the LCC of the product is at least 70% lower than the common EPS sold with DECT phones today.

The BOM in EcoReport format is listed below. With 64 g (without packaging, European plug version), this switch-mode power supply is among the most light weight ones available on the market currently.

Table 6-2 – BOM entries for Power Integrations DECT Phone EPS

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	Upper case	9,9	2-TecPlastics	12-PC
3	Lower case	7,1	2-TecPlastics	12-PC
4	Screws (3x)	1,4	3-Ferro	21-St sheet galv.
5	Clip (2x)	0,5	3-Ferro	25-Stainless 18/8 coil
6	Plug (mainly metal)	6,7	4-Non-ferro	31-CuZn38 cast
7				
8	Electronic assembly			
9	PWB	2,1	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
10	Capacitors (electrolytic) 3x	3,0	6-Electronics	44-big caps & coils
11	Capacitor (others) 3x	0,5	6-Electronics	44-big caps & coils
12	Coils + transformers 2x	5,7	6-Electronics	44-big caps & coils
13	*Diodes (6x)*	0,9	6-Electronics	47-IC's avg., 1% Si
14	Ferrite	0,5	3-Ferro	24-Ferrite
15	IC's	0,5	6-Electronics	47-IC's avg., 1% Si
16	THT Resistors *(4x)*	0,8	6-Electronics	48-SMD/ LED's avg.
17	Solder	0,3	4-Non-ferro	52-Solder SnAg4Cu0.5
18				
19	Cables			
20	Copper wire	9,6	4-Non-ferro	29-Cu wire
21	PVC	9,6	1-BlkPlastics	8-PVC
22	Plug	4,9	7-Misc.	45-slots / ext. ports

EPS (high output power range) for Laptops

Manufacturer	AcBel Polytech, Inc.
Product Name	API 3 D25-380
Average Efficiency	90%
Application	Laptop computer
Output Power	150 W
Output Voltage	19 V
Output Current	7.9 A

This is an EPS for high end laptops (desktop-replacement). The output power of 150 W requires power factor correction, which normally compromises energy efficiency. However, this reference product is claimed to achieve an average of 90% efficiency in active mode and still achieving very good power factor correction (average of 0.99 across four loading points).

EPS (high output power range) for Laptops: Breeze Lite

Designer	Commergy Ltd
Product Name	Breeze Lite Adaptors
Average Efficiency	90.6%
Application	Laptop computer
Output Power	50 W - 180 W
Output Voltage	5 V - 24 V
Output Current	2 A - 15 A

Breeze Lite adaptors with >92% full-load efficiency and almost as high average efficiency have been evaluated for a major notebook line. Product applications are to enter production in the first quarter of 2007.

The adaptors use proprietary hysteric control buck/half bridge combination. This topology solves a major efficiency issue for EPS with 35% less power losses than best in class adaptors - enabling a 35% size reduction at a competitive cost. No-load losses are 0.45 W. Moving efficiency from 85% to 93% can lead to a 7-fold reliability improvement, according to Commergy.

The BOM is equivalent in number of components with a standard high efficiency EPS, but using approximately 35% less plastic and 35% less copper. Silicon and other electronic components are equivalent.

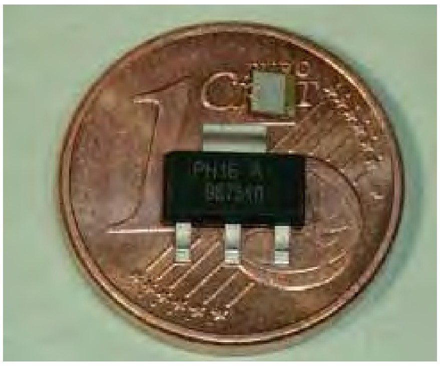
6.1.2 "ULTRA-SMALL" EXTERNAL POWER SUPPLIES

There is a trend towards very small external power supply units, driven by consideration of user convenience and portability. High efficiency and miniaturisation normally go hand-in-hand and some of the efficient EPS mentioned in 6.1.1 could also have been included in this section – and vice-versa. In addition, the trend towards smaller EPS units addresses one of the major aspects identified during the base case assessments (Task 5), namely the reduction of size and weight of certain components, printed wired board, and housing.

Already in 2001, FRIWO introduced their PP 3 product series to the market, which comes close in size to a standard AC plug. They realised this kind of EPS with flip chip technology, which allows a much smaller size as the ASIC is assembled as a bare IC[3] active side top-side down, but this requires also a more sophisticated assembly technology as the pitch on the printed wired board shrinks and needs a fine pitch PCB layout and high precision assembly technology. This product was introduced to the market successfully at competitive price.

Figure 6-1 illustrates the size difference between a bare die and packaged MOSFET switching semiconductor. These exemplary MOSFET are not from FRIWO, but they show what the size reduction that can be achieved by using flip chip technology. A similar approach has also been followed in the MikroNetz project (see section 6.5.1 below).

Figure 6-1 – MOSFET for low power EPS in a packaged and bare die version[4]



In 2003, Phihong presented their series of "ultra-small" adapters for the low power segment, claiming "lower costs, smaller sizes and increased energy efficiency."[5]

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3 The size reduction actually comes from the fact, that the IC is not packaged at all, which usually results in a much larger footprint – this larger footprint is usually intended to allow for standard assembly processes

4 E. Jung, I. Kolesnik, K.F. Becker, R. Aschenbrenner, H. Reichl: Area Array Contacts to Assemble a 3D Transformer for a Miniaturized Voltage Converter, IEMT conference, USA, 2004

5 Phihong: Phihong's Ultra-Small Accessories Provide Economical Efficiency for Custom Applications, Fremont, CA (July 21, 2003), Press Release

Figure 6-2 – Phihong's ultra-small power supplies[6]

Since 2003, other manufacturers also released external power supplies of similar small size. A start-up company Easybrick (Denmark) realised a patented in-plug EPS a few years ago, but failed with their licensing strategy. They targeted at 0.60 USD manufacturing costs[7]. In the meantime Easybrick has sold their business. The technology is now with Tinyplug Technology (Shenzhen)[8]. Tinyplug states a performance for their universal EPS as listed below. With a stated weight of **23g**[9] and dimensions of 40.8 × 35.0 × 14.3 mm their EPS is smaller than any other known EPS on the market (Figure 6-4).

TinyPlug EPS

Designer	Tinyplug Technology (Shenzhen) Ltd.
Product Name	Tinyplug
Efficiency	> 68%
No-load losses	< 0.3 W
Application	Mobile phone, MP3/MP4, Bluetooth Devices
Output Power	3 – 5 W
Output Voltage	n.a.
Output Current	n.a.

Figure 6-3 – Tinyplug EPS[10]

6 http://www.phihong.com/html/pr_ultrasmall.html
7 Source: C. Jehle, Project MikroNetz, internal communication, 2004/05
8 C. Jehle, personal communication, 10 January 2007
9 Most likely cable excluded
10 http://www.tinyplug.net/english/products.htm

6.1.3 EXTERNAL POWER SUPPLIES WITH PRIMARY INTEGRATED IC

The concept of integrating the integrated circuit on the primary side has been realised by FRIWO in recent years for EPS in low power range (mobile phone chargers up to 5 W)[11]. Other manufacturers such as iWatt and Power Integrations have also followed this concept.

A 5 W EPS with voltage and current regulation on the primary side achieves less than 200 mW no-load losses and an average efficiency of 67%. Such an external power supply is on the market since 2000. Based on a newly developed ASIC[12], FRIWO introduced a 3 W power supply in 2005 with no-load losses below 100 mW and an average efficiency of 64%.

Currently, 65 W EPS with primary integrated ICs can achieve no-load losses below 300 mW at an average efficiency of approximately 82%.

iWatt, for their digital PWM controller, claims compliance with CEC/EPA no load power consumption and average efficiencies. The iWatt controller is designed for low power AC-DC adapters for up to 20 W output power (example applications: mobile phones, PDAs, digital still cameras, etc.).

Primary-side regulation results in significant reduction in the number of electronic components. A 4 W power supply unit with primary integrated IC weights approx. 90 g in total. Table 6-3 lists an abridged BOM of such an EPS[13]. Such a design can be realised with less than 30 electronic components and significantly reduced printed wired board size.

The primary-side regulation does not need an optocoupler, which usually provides the feedback from the secondary-side to the primary-side ensuring galvanic isolation.

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11 M. Bothe: Die Menge macht's – Energie-Effizienz von Klein-Stromversorgungen, Elektronik, Ecodesign 2006

12 Application specific integrated circuits

13 For comparison: also the DECT phone power supply from Power Integrations for which a BOM is provided above is based on a primary integrated IC. Power Integrations realised their EPS with THT technology only, allowing a "simpler" manufacturing technology, whereas FRIWO's layout is based on a hybrid assembly process with SMD and THT

Table 6-3 – BOM for a power supply unit with primary integrated IC

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Housing			
2	PC/ABS	25,3	2-TecPlastics	12-PC
3	Brass	5,2	4-Non-ferro	31-CuZn38 cast
4	Steel	0,3	3-Ferro	25-Stainless 18/8 coil
5	Electronic assembly			
6	PWB	2,8	6-Electronics	49-PWB 1/2 lay 3.75kg/m2
7	Big caps & coils (THT)	12,2	6-Electronics	44-big caps & coils
8	IC's, transistors, diodes	4,1	6-Electronics	47-IC's avg., 1% Si
9	SMD components	0,2	6-Electronics	48-SMD/ LED's avg.
10	Solder	1,0	4-Non-ferro	52-Solder SnAg4Cu0.5
11	Cables			
12	Copper wire	13,2	4-Non-ferro	29-Cu wire
13	PVC	23,2	1-BlkPlastics	8-PVC
14	Plug	0,6	7-Misc.	45-slots / ext. ports
15	Nylon	0,6	2-TecPlastics	11-PA 6
16	Miscellaneous			
17	Heatsink	1,3	3-Ferro	25-Stainless 18/8 coil

6.1.4 STANDARD BATTERY CHARGERS: MICROPROCESSOR CONTROLLED CHARGING

Limited attention has been paid to the energy efficiency/consumption of the standard battery chargers. Product specifications lack information on these aspects and quantitative comparison between chargers is difficult due to the lack of widely used test standards. However, chargers using microprocessor controlled charging technology stand out as BAT candidates.

Microprocessor controlled chargers typically include most, if not all, of the following features:

- possibility to fast charging (charging times as low as 30 minutes)
- negative delta V (- delta V) cut-off function protecting batteries from overcharging, for better life time battery performance
- efficient charging
- independent microprocessor controlled charging circuits ensuring the optimum charging for each battery
- improved charging algorithms allowing batteries to accept a more complete charge
- NiCd and NiMH batteries can be mixed and charged at the same time; batteries can be charged in singles or groups
- detection of defective cells
- automatic charge and discharge function; current automatically selected for the different battery sizes (AA,AAA, C, D and/or 9V)

Many manufacturers offer such microprocessor controlled “intelligent” or “smart” chargers. However, they represent only a minor part of the overall market.

6.1.5 IMPROVED POWER TOOL BATTERY CHARGERS

Microprocessor control plays an important role in the state-of-the-art power tool chargers too. However, the microprocessor itself consumes power as well, an aspect which should not be neglected. According to Black and Decker[14], terminating chargers have progressively benefited from the reduction in microcontroller power demands as a consequence of reduced silicon feature size. While the primary motivation for this improvement has more to do with the yields and costs of the integrated circuit manufacturing process, manufacturers have been able to steadily reduce the power demands on the low voltage power supply for their charger microcontroller.

A charger from a power tool manufacturer employs a constant current switch-mode topology. This charger also employs a microprocessor control for charge termination. The microprocessor is associated with low voltage power supply circuit. In addition, the switch-mode converter block requires a high-side drive that consumes power even when the converter is not in use. The manufacturer provided data on the conventional product as well as on a potential improved model, which could be considered as BAT. Power consumed in standby mode, along with the breakdown by circuit block is shown in Table 6-4. In this particular design, the power consumption associated with standby is present during maintenance, recharging, and equalisation modes. Consequently, improvements in standby losses also influence losses in these other modes. Table 6-4 also reflects BAT assumptions about energy improvements in these areas and shows the estimated impact upon overall efficiency as measured by the ENERGY STAR method. Since the conversion efficiency of this charger is fairly good already (>85%), the principal focus for energy improvement is in the "overhead" functions of the charger.

14 Personal communication with Colin Thirlaway (Black and Decker)

Table 6-4 – Comparison of a current model of 1 hour (professional) power tool charger and a corresponding feasible assumed BAT

	Charger A for professional power tools	
	Current model	**Feasible "BAT"**
Standby power	5 W	2.5 W
Maintenance power	5.5 W	3.0 W
Gate drive supply	2.9 W	1.5 W
Microcontroller & Low voltage PS	2.1 W	1 W
ENERGY STAR BCS[15] consumption	258 Wh	138 Wh
Energy Ratio	6.0	3.2

Another manufacturer stated that their "premium" charger for professional power tools achieves 83% efficiency under full load and a no-load consumption of 2.1 W.

In principle, BAT for professional power tool chargers can also be applied to do-it-yourself (DIY) tool charger. However, this may result in prohibitive product prices. The previous manufacturer also provided a comparison case for a DIY power tool charger and assumed feasible "BAT" (Table 6-5). This charger does not employ a microcontroller since it is not the terminating type. The principal improvement option with these chargers is to reduce the current during maintenance mode by employing a crude terminating scheme (even though one would not be required for safety).

Table 6-5 - Comparison of a current 6 hour (DIY) power tool charger and a corresponding feasible BAT

	Charger B for DIY power tools	
	Current model	**Feasible "BAT"**
Standby power	0.9 W	1.7 W
Maintenance power	9 W	4 W
ENERGY STAR BCS[16] consumption	335 Wh	164 Wh
Energy Ratio	9.8	4.8

15 Battery charging system
16 Battery charging system

6.2. STATE-OF-THE-ART ALREADY ON THE MARKET (COMPONENT LEVEL)

The highly efficient external power supplies presented above owe their performance to improved and efficient components. Similar efficiencies can be achieved using different combinations of individual components. Some of the state-of-the art components are presented here.

6.2.1 EFFICIENT SWITCH-MODE TECHNOLOGY

- **"EcoSmart®" by Power Integrations**

Introduced already in 1998, this energy efficient power supply technology enables a switch-mode power supply design to operate with high efficiency when in standby or in no-load. The use of innovative integrated circuit (IC) technology eliminates external components and thus lowers system cost and improves reliability considerably. As a consequence, switcher designs have become cost-competitive compared to linear transformers even under 5 W.

Currently, four Power Integrations off-line power conversion IC product families incorporate EcoSmart technology, covering a power output range from 0 W to 210 W, which comprises most of the AC-DC power supplies worldwide.

Table 6-6 – Sample reference designs with standby and no-load energy consumption

APPLICATION	REFERENCE DESIGN	OUTPUT		P_{OUT} at 1 W INPUT (W)		P_{IN} at NO-LOAD (W)		MEETS 1 WATT STANDBY	MEETS EU NO-LOAD SPEC*	MEETS CEC**
		W	VDC	115 V	230 V	115 V	230 V			
AC Adapter/Charger	EP-14	3 W	9 V	0.70	0.58	0.09	0.20	✓	✓	✓
AC Adapter/Charger	EP-16	2.75 W	5.5 V	0.68	0.64	0.23	0.27	✓	✓	✓
AC Adapter/Charger	EP-54	2.75 W	5.5 V	0.66	0.61	0.13	0.20	✓	✓	✓
AC Adapter/Charger	EP-73	2.28 W	5.5 V	0.58	0.52	0.16	0.24	✓	✓	✓
AC-DC Power Supply	EP-34	30 W	12 V	0.67	0.59	0.18	0.29	✓	✓	✓

- ***PeakSwitch™*** **by Power Integrations**

Some typical end-appliances of EPS, such as inkjet printers, require power supplies with peak-to-continuous load ratios up to 300%. The conventional approach to designing such power supplies has involved sizing all of the power components to deliver the peak power levels continuously as if they were the normal load conditions. This approach impacts the cost and size of the power supply, causing also high no-load and standby power consumption.[17]

A power-conversion IC with peak power management technology can significantly improve the power supply performance in such applications. Such an IC is offered, for example, by Power Integrations. Their *PeakSwitch* IC (one

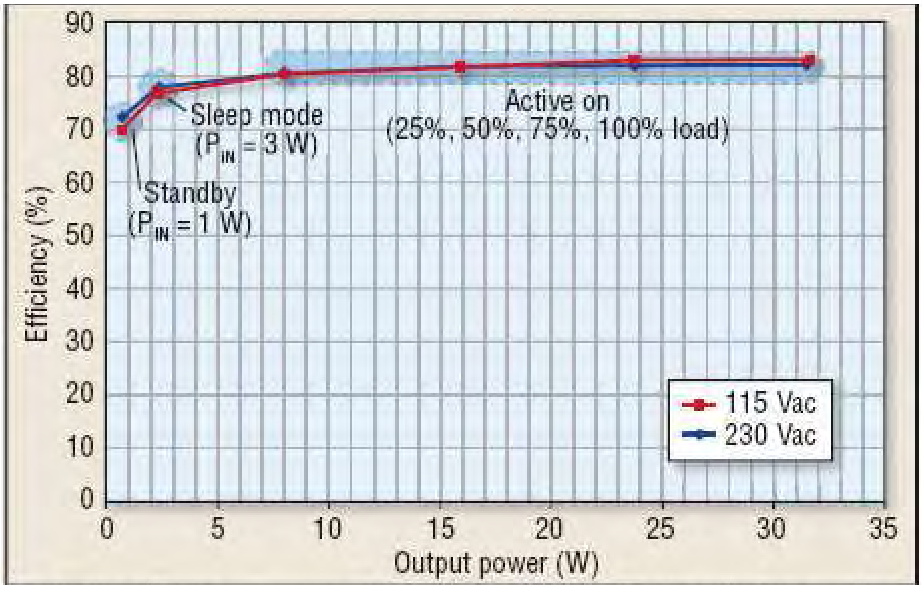
[17] Bäurle, S. (2006) Switching Chip Tames Power Peaks. Power Electronics Technology, July 2006: Pp 14-19.

of the product families with EcoSmart technology, see above) incorporates a 700-V power MOSFET, an oscillator with frequency jittering for low EMI, a high-voltage switched current source for start-up, and a current limit in a single monolithic device. In addition, a variety of protection features including auto-restart, line undervoltage sense, and hysteretic thermal shutdown have been added.

The simple on/off control scheme with four discrete current limit levels responds to a feedback signal and enables or disables primary-side switching in order to transfer energy appropriate to the load conditions at the output of the power supply. This allows the *PeakSwitch* to operate at very high switching frequencies of up to 277 kHz.

According to the manufacturer, the active-on efficiency that is achieved easily meets the minimum value of $(0.49 + 0.09 \times \ln(32)) \times 100\%) = 80.2\%$ as specified by the California Energy Commission (CEC) and others. The active-on efficiency are nearly constant for all loads as depicted in Figure 6-4.

Figure 6-4 – The efficiency vs. output power for the *PeakSwitch*-based circuit[18]



Fairchild Power Switches

Fairchild Power Switches (FPS) are highly integrated off-line power switches with a fully avalanche rated SenseFET and current mode PWM IC offering Advanced Burst Mode Operation to meet low standby power regulations and achieve improved efficiencies. EMI emissions are reduced through intelligent frequency modulation, According to manufacturer, in comparison to discrete MOSFET and controller or RCC switching converter solution, the FPS simplifies designs by reducing total component count, design size, and weight while at the same time improving system reliability and lowering costs in target applications.

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18 Bäurle, S. (2006) Switching Chip Tames Power Peaks. Power Electronics Technology, July 2006: Pp 14-19.

BIAS Full power supply component

Manufacturer	BIAS Power LCC
Product Name	BPS Series micro switching power supply module
Average Efficiency	See below
Application	Low power or stand-by applications
Output Power	2.0 W (also 0.5 and 1.0 models for standby applications)
Output Voltage	8 or 14 V
Output Current	0.166 – 0.250 A (0.062 – 0.125 A for models of 0.5 and 1.0 W)

Bias Power LLC manufactures line patented low isolated AC-DC supplies, based a concept known as “line-synchronous switching technology. In principle, it is a full power supply component to be mounted on a printed wired board but it can also be integrated in an EPS.

According to the manufacturer, the new BIAS BPS Series micro switching power supplies are the world’s smallest (Figure 6-5), and most efficient low-power switchers. This product offers power conversion from AC to DC without generating EMI (patented technology) and with approximately 130 mW of standby power at 230 V input (Figure 6-6). Based on the product specification sheet, for a 14V model the average and maximum efficiencies are approximately 64% and 69% respectively. For a 8V model, these parameters are 61% and 68%. (Figure 6-7)

Figure 6-5 – BIAS BPS series power supplies in actual size

Figure 6-6 – No-load power vs. Input voltage of BIAS 2W power supply module

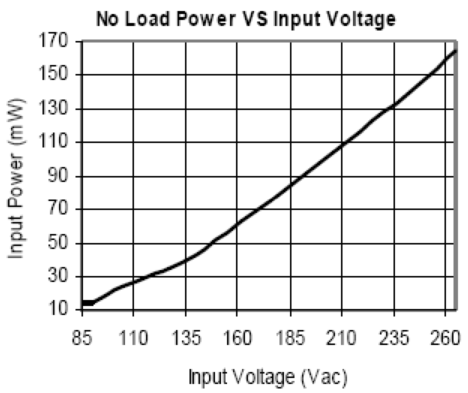
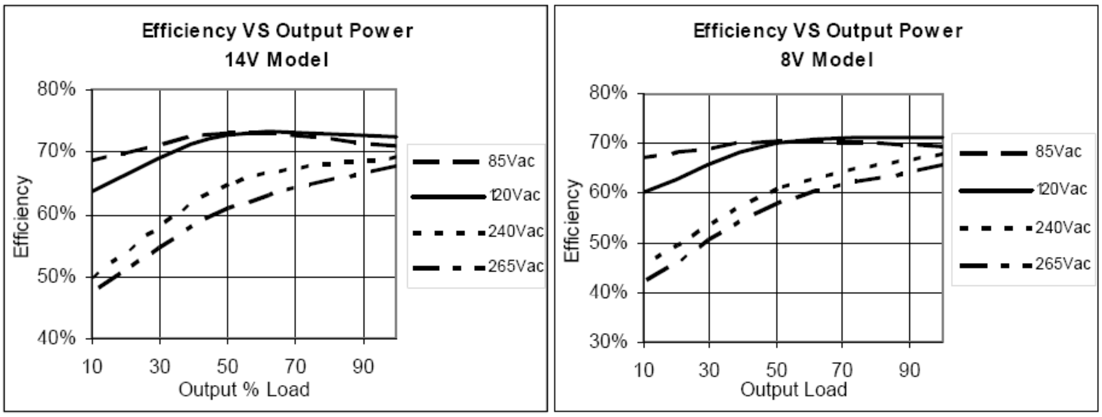


Figure 6-7 – Efficiency vs. Output load for BIAS 2 W power supply module



The small size offers key advantages to consumers beyond energy saving. These power supplies are only slightly larger than a standard AC plugs, increase portability and convenience for consumers and reduce packaging and shipping costs for manufacturers (Figure 6-5).

This product demonstrates the fast development in the power supply sector. In 2004 its prototype was an award winner in the *Open Category* of the “efficiency challenge” contest jointly organised by US EPA and CEC abd within two years it has become a fully commercialised product.

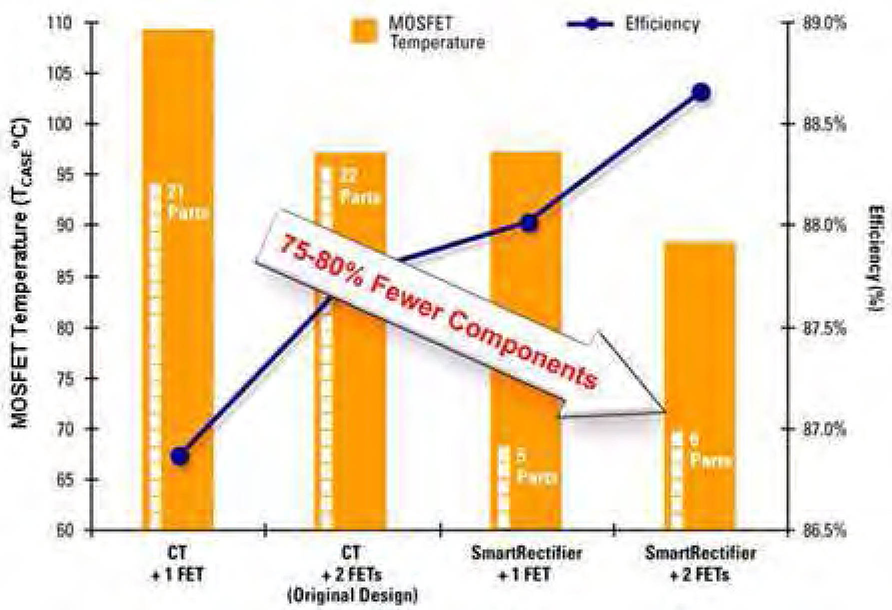
- ***Smart Rectifier*™ IC by International Rectifier**

This is a secondary control IC with built-in gate drive. It operates independently from the primary side, using a proprietary ‘Voltage Level Detection’ technique to minimise wasteful secondary reactive currents to maximise secondary efficiency. The proprietary 200V HVIC technology allows direct sensing and control. The IC is applicable for high power flyback and resonant half-bridge converters, for example for laptop EPS.

The technology enables high efficiency and higher power density, complying with CEC 80plus and 1 W stand-by requirements. According to the manufacturer, compared to a current transformer (CT) and TO-220 SR FETs (Figure 6-8) in a 120 W laptop adaptor (19.5V, 6.15A), this IC enables

- 1% efficiency improvement
- 10℃ lower temperature, enabling ‘no heat sink’ des igns
- 75% fewer components, allowing 20% lower system cost

Figure 6-8 – Comparison of Smart Rectifier with conventional current transformer technology



Single-Stage Flyback Topology for Power Supplies with PFC

Power supplies in the range above 75 W where power factor correction is required usually come with a two stage design: first the power factor correction followed by the main power conversion stage in flyback topology.

Both stages can be combined in one with a single-stage flyback topology as realised by, for example, ON Semiconductor and Energy Recovery Systems Corporation[19]. Their design is based on the controller NCP1651, "an active power factor correction controller designed for operation over the universal input range (85 Vac – 265 Vac) in 50/60 Hz power systems … [for] mid-high output voltage requirements and eases the task of meeting the IEC 1000-3-2 harmonic requirements." This technology is also provided by iWatt[20].

Main environmental improvements of the single-stage flyback topology are the achieved reductions in power consumption. For no-load ON Semiconductor claims a P_{in} of 390 mW at an input voltage of 230 V AC.

The efficiencies are not stated in accordance with the definition of "average efficiency", i.e. the arithmetical average of efficiencies at 25, 50, 75 and 100% load, but at 4.5 A, which corresponds to approx. 100% load[21]: 91.3 % is stated

19 ON Semiconductor: 90 W Notebook Ac-Dc Adapter – Reference Design Documentation Package, TND317/D, Semiconductor Components Industries, LLC, July, 2006 – Rev 4

20 J. L. Zheng et al.: A Novel Multimode Digital Control Technique for Single-stage Flyback Power Supplies with Power Factor Correction and Fast Output Voltage Regulation, APEC, March 2005

21 Output voltage: 19,5 V

for 230 V AC input. From the given data, for lower currents an average efficiency of at least 90% can be assumed[22].

iWatt provides efficiency data for an 90 W, 19.5 V AC-DC power supply for 230 V AC input: Between 2 and 4.62 A output load[23] the efficiency exceeds 88%. At 100% load efficiency of 90.2% is achieved; at 25% load the efficiency is in the range of 82% totalling to an average efficiency of at least 87%[24].

Furthermore, the single-stage design results in fewer components than for the conventional two-stage approach.

6.2.2 IMPROVED TECHNOLOGY FOR ELECTRONIC HALOGEN LIGHTING TRANSFORMERS

- **IR2161 by International Rectifier**

IR2161 is an intelligent converter control IC specifically designed for electronic transformers of low voltage halogen lamps. The compact 8-pin device incorporates a 600V half-bridge driver, advanced overload and short-circuit protection circuitry and adaptive control techniques. The integrated design reduces parts count by 20%, simplifies circuits and increases reliability, according to the manufacturer.

The IR2161 is based upon International Rectifier's high-voltage junction-isolation (HVJI) IC technology. It can adapt to changing supply voltage, frequency and lamp conditions. Adaptive dead-time control is a key feature of this IC, which increases transformer reliability by continually maintaining soft switching. Soft start limits inrush current to the lamp filament to boost lamp life.. The chip also is compatible with external triac wall-switch light dimmers.

Halogen lamps are not inherently energy efficient, so the motivation for using the intelligent ICs is space savings, reliability and improved lamp life. The technical specifications of IR2161 do not provide data on the energy efficiency implications of this new IC, which thus cannot be assessed.

6.3. STATE-OF-THE-ART IN APPLIED RESEARCH FOR THE PRODUCT (PROTOTYPE LEVEL)

Some of the EPS and BC at the prototype level participated in the "efficiency challenge" contest jointly organised by US EPA and CEC. The products selected in the *Open Category* showcases the most efficient power supply designs from industry and academia without cost or packaging constraints.

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22 The efficiencies stated for 1,5 A, 2,5 A and 3,5 A (corresponding to approx. 33%, 56%, 78% load) are 89,3%, 90,7%, and 91,3% respectively At 230 V AC input.

23 4.62 A being the rated maximum

24 J. L. Zheng et al.: A Novel Multimode Digital Control Technique for Single-stage Flyback Power Supplies with Power Factor Correction and Fast Output Voltage Regulation, APEC, March 2005

High efficient EPS (low power range)

Designer	FRIWO
Product Name	n/a
Average Efficiency	83.5% at 230 VAC input
Application	Fast chargers for batteries of smart phones, PDAs and digital cameras
Output Power	5 W
Output Voltage	Not known
Output Current	1.3 A

Very high efficiencies for power supplies in the low power range are achievable with a combination of primary integrated IC and synchronous power rectification: FRIWO recently developed this power supply prototype, based on a prior product generation, with an relatively high output current of which makes this circuitry a preferable option specifically for fast chargers for batteries of smart phones, PDAs and digital cameras[25]. The prototype achieves a high average efficiency. Although synchronous rectification requires additional power, the overall no-load losses of the prototype are well below 0.15 W. Compared to the prior product generation without synchronous rectification, the dimensions did not change and there were no significant BOM changes.

Ultra low stand-by power charger for mobile phone

Designer	Salcomp plc
Product Name	n/a
Average Efficiency	63% at 230 VAC input
Application	Mobile phone
Output Power	5.2 W
Output Voltage	5.7 V
Output Current	800 mA

This BNAT approach is based on the assumption that for applications, such as mobile phones, no-load power consumption is dominant. Consequently the product is optimised for no-load power; no effort has been put to maximise its efficiency. In fact, this BNAT has lower efficiencies than many products already on the market. However, the required maximum no-load power is only 0.01 W at 230 V AC input.

Ultra low no-load power is possible to achieve with relatively slight modification if the ripple voltage (due to burst mode operation) is allowed to increase. In the best case, only two additional SMD components are needed. Cost impact in this approach are minor, however, ripple specification in the mobile phone - EPS interface must be modified (EPS detection).

25 M. Bothe: Die Menge macht's – Energie-Effizienz von Klein-Stromversorgungen, Elektronik, Ecodesign 2006

Stand-alone battery charger

Designer	Hong Kong Polytechnic University
Product Name	Not applicable
Average Efficiency	74%
Application	Stand alone AA battery charger
Output Power	2.5 W
Output Voltage	6.25 V
Output Current	400 mA

This standard AA battery charger has low parts count, very good efficiency for a 2.5 W output power, and no-load of 0.16 W.

The high conversion efficiency is obtained through an optimized selection/design of control IC, converter topology, output transformer, operation mode, MOS switch, and output rectifier.

In the selection of control IC, an NCP1215A is used. This IC uses a variable-off-time technique to reduce the standby-mode power dissipation of the converter. In the regulator, a flyback converter is used. A well-designed flyback transformer is used to reduce the loss due to the leakage inductance of the transformer and the resistance of the transformer windings. The operation mode is optimally selected to strike a balance between switching loss and conduction loss. The MOS switch and output rectifier are also carefully selected to reduce their switching and conduction losses.

Charger for cordless vacuum cleaner or standard AA batteries

Average efficiencies of these types of EPS are around 50% in active mode. Achieving 68% efficiency represents a great leap in what is possible with power supply efficiency in this product type.

Designer	University of Illinois at Urbana-Champaign
Product Name	PB00351
Average Efficiency	68%
Application	Cordless vacuum or stand alone AA battery charger
Output Power	2.5 W
Output Voltage	6 V
Output Current	417 mA

The high efficiency of this converter design system comes from two features: the converter uses micropower logic to achieve very low overhead energy consumption; and burst-mode control is used to halt switching entirely for light loads. Power factor correction for the system is automatic through the use of an off-line flyback converter in discontinuous current mode for all load levels.

Generic EPS for computer peripherals and DECT Phone

This EPS demonstrates outstanding active mode efficiencies and typical output power is at 60% in active mode.

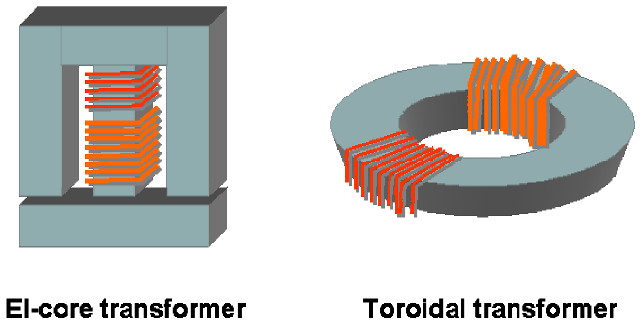
Designer	School of Engineering, Dartmouth College
Product Name	Big Green
Average Efficiency	88%
Application	Office phone, computer peripherals
Output Power	11.2 W
Output Voltage	7.59 V
Output Current	1.48 A

In most EPS, the magnetic components (transformers and inductors) are responsible for the largest fraction of the losses. While designing this EPS all the losses in the main high-frequency transformer were accurately modelled and the design was optimised to minimise these losses. The transformer uses litz wire to achieve very low winding losses. The circuit is a flyback converter, a standard circuit, but with careful attention to details in order to minimise losses throughout a synchronous rectifier was used on the input with an innovative low-power control circuit.

Toroidal Transformer

External power supplies based on linear technology commonly use an EI-core transformer. The geometry of this kind of core can be produced easily in high volumes but results also in inefficiencies due to magnetic flux directions vertically above and below the coils. The toroidal core geometry provides the same orientation for magnetic flux and magnetic domains, resulting in higher efficiency. (See Figure 6-9)

Figure 6-9 – Transformer core designs



For higher voltage linear transformers, toroidal transformers are a mature technology competing with EI-core transformers. But due to manufacturability constraints they have not been used in the low power range of external power supplies. Recently PanPower AB developed a patented manufacturing process for toroidal transformers for this low power range[26,27]. The PanPower

26 Personal communication with Alan Ericsson and Jörgen Ekelöf

27 J. Ekelöf, A. Ericsson: The PanPower Transformer, EEDAL '06, Millennium Gloucester Hotel and Conference Centre, London, UK, 21 – 23 June 2006

transformer is expected to go into first mass production during the 2nd half of 2006 and will be available for the open market on license basis.

Following are the advantages of such an improved toroidal transformer as proclaimed by PanPower.

- Simple high speed winding of a straight bobbin resulting in a simple high speed production process, low cost production.
- Possible to produce in small sizes down to 1 VA or even less.
- The window area (centre hole) can be reduced to a minimum resulting in smaller size and lower weight, less material use and lower energy loss. In addition, no stamping of core material, no material waste.
- Low price, even lower than for the EI-core transformer.
- A robust, solid, low cost transformer with a long lifecycle and which will meet future global requirements on energy savings, in most cases even when using standard non-oriented low cost silicon-steel.

The energy efficiency of toroidal transformers is significantly higher than that of EI core transformers, but still depends on other factors as well, such as the grade of the steel core. Table 6-7 presents measured efficiencies and no-load losses for PanPower AC-AC and AC-DC toroidal transformers. The values are based on the use of Schottky diodes and non-oriented silicon steel. With high-grade grain oriented steel no-load losses down to 250 – 300 mW as well as higher efficiencies might be feasible for the 5 – 10 W transformer range[28].

Table 6-7 – Energy efficiency and no-load losses of toroidal transformers

Input	Rated Output	No-load loss	Efficiency rate[29]
230V / 50Hz	12VDC / 0.25A	0.45W	65%
	12VAC / 0.25A	0.44W	67%
	5VDC/1A	0.47W	63%
	5VAC/1A	0.47W	65%
	12VDC/0.67A	0.50W	68%
	12VAC/0.67A	0.50W	68%

Compared to EI-core transformers, the toroidal one comes with approximately one third of the weight of steel for the core and roughly 10 to 20% less copper. The bobbin comes with an additional plastic housing to hold the coils.

28 Personal communication with Alan Ericsson

29 At 100% load. As toroidal transformers have higher efficiencies at partial load (according to Alan Ericsson), the stated efficiencies rather underestimate actual average efficiencies of these transformers.

6.4. State-of-the-art at component level (prototype, test, and field trial level)

Components: ASICs

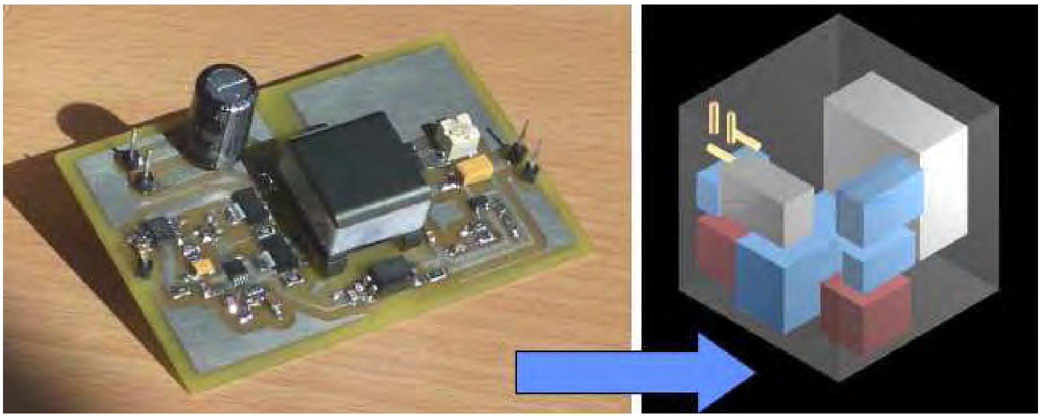
Application specific integrated circuits (ASICs) have been developed in the past for power supply units, e.g. by ELMOS within the project MikroNetz to realise resonant switching for the low power segment[30]. However, this ASIC is a demonstrator chip, intended to perform also signal transfer tasks in parallel and therefore not intended for “power supply only” functions.

6.5. Best Not yet Available Technologies (BNAT)

6.5.1 Further miniaturisation

Currently, there are power supply units under development for the low power range with a size of approximately 1 cm^3 (housing, plugs and cables excluded)[31]. Such prototypes already exist and the figures below (Figure 6-10 and 6-10) illustrate the next step, showing the concept for 3D assembly of power supply “sugar cubes” and a demonstrator for a power supply unit based on the Match-X concept[32].

Figure 6-10 – Scheme for sugar-cube size power supply unit[33]



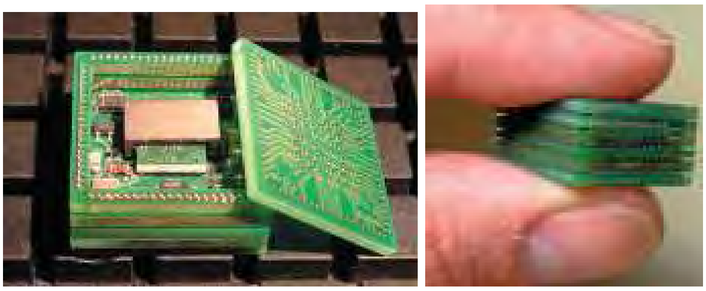
30 Skytron, ELMOS: Technische Umsetzung auf Basis eines Resonanzwandlers, Project MikroNetz, final presentation, November 16, 2006, Münich

31 A. Middendorf et al. (Fraunhofer IZM): Abschlussbericht Projekt MikroNetz, Berlin, 2006

32 R. Schmidt: Entwicklung von Aufbau- und Verbindungstechnologien für ein Schaltnetzteil im Kleinleistungsbereich auf Basis des Baukastens der Mikrosystemtechnik, Project MikroNetz, final presentation, November 16, 2006, Munich

33 E. Jung, I. Kolesnik, K.F. Becker, R. Aschenbrenner, H. Reichl: Area Array Contacts to Assemble a 3D Transformer for a Miniaturized Voltage Converter, IEMT conference, USA, 2004

Figure 6-11 – MikroNetz demonstrator power supply unit based on the Match-X concept



The demonstrator based on the Match-X concept is not solely intended for external power supplies, but can also serve as an integrated part, including only DC-DC conversions.

6.5.2 BNAT FOR POWER TOOL BATTERY CHARGERS

Maintenance and standby contribute significantly to the overall lost energy in the average power tool battery charging system. To this end, any method of reducing consumption during one or both of these modes will have a profound impact in overall energy consumption. The most promising advancement in this area is not in conversion topology but in cell chemistry[34], highlighting the important role the system can play in case of battery chargers.

Li-ion cells require no maintenance charge and therefore the charging system can "hibernate" after termination with little or no energy consumption. Unfortunately, Li-ion cells have some serious risks including fire and explosion. Presently, additional monitoring circuitry is employed in the battery pack and the charger to attempt to mitigate these risks with corresponding increases in power to operate these circuits. Even with these methods, power tool appliance and battery manufacturers are proceeding cautiously in adopting Li-ion, since these represent significantly more severe application environments than do the more pedestrian mobile phone and laptop uses of Li-ion.

What is hoped for by power tool and appliance manufacturers is an inherently "safe" Li-ion cell that requires no more care than nickel-based cells to guard against accidents at a competitive cost per Watt-hour. This cell technology would have a profound impact upon battery charging system energy usage and would be acceptable to consumers and manufacturers. However, this would necessitate a completely different charger and battery pack design.

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34 Personal communication with Colin Thirlaway (Black and Decker)

6.5.3 SOLAR CHARGERS

A number of companies have launched universal solar chargers for portable data and communication appliances. These chargers are actually a hybrid between external power supply and an energy storage device. Their internal Li-ion battery can be charged either by solar energy or mains electricity; this power is then available to power/charge any hand held device.

As an example, charging the internal battery of an exemplary solar charger takes 8-10 hours of direct sunlight. From the mains the internal battery will fully charge in approximately 4 hours. A charged internal battery stores enough power to charge an average mobile phone at least two times, at the same rate as a conventional charger. The accumulated energy can be stored for more than one year in the internal battery. A number of tips for common appliances is normally provided with a charger to allow compatibility with a range of end-appliances. Following are some exemplary models:

Model 1

Manufacturer	Solio
Rated Output	4 -12V, 0 - 1 Amp (max)
Solar panel output	155mA @ 6V
Weight	156 grams
Internal Battery	Rechargeable 3.6 volts, 1600mAh Li-ion
Wall charger	6v / 420 mAh
Dimensions	11.94 x 3.30 x 6.35 cm

Model 2

Manufacturer	Solar Style Inc.
Applications	mobile phones, smart phones, MP3 players and other electronic devices with medium energy consumption/battery needs
Rated Output	5.5V (>300mA)
Solar panel output	7.0V 80mA(x2)
Weight	70 g
Internal Battery	(Li-polymer): Capacity- 720mAh; Voltage- 3.7V; mAh-720
Charge	Full Charge, AC/Car= 4-5 h, Sun= 12-14 h
Dimensions	97.5x53.2x16 mm

THIN-FILM SOLAR TECHNOLOGY

As an alternative to the common solar panel technology (based on silicon wafers), think-film solar technology has seen important developments in recent years. Further growth in this technology is expected in the coming years and a significant impact on the consumer electronics industry is foreseen. Thin-film solar technology offers an alternative especially for lower wattage devices.

In thin-film solar technology, a thin layer of light conducting semiconductors is printed on a thin, flexible metal foil. The production costs for thin-film solar panels are as little as 10% of the cost of current solar panels (based on silicon wafers). Material use is less than 1% in comparison to silicon wafer-based solar cells. Consequently, the price per kWh and size are significantly reduces compared to current solar cells. Efficiency has been a weak point of thin-film technology, but continuous development is pursued on this issue.

6.6. OTHER RELEVANT TECHNOLOGIES AND PRODUCTS

The options discussed here can neither be seen as an improvement in the existing EPS/BC nor as an alternative to them but rather related products which may have an influence on the future market of EPS/BC.

6.6.1 DIRECT METHANOL FUEL CELLS (DMFC)

The fuel cell technology has been in development during recent years and is expected to arrive in the market in the near future. A DMFC, just like a Li-ion battery, is an electrochemical device used for converting and storing power. A DMFC has distinct advantages over a traditional Li-ion battery but also suffers some drawbacks. First, a DMFC has an energy density several factors higher than typical Li-ion battery and as a result of which it can store more energy without appreciably adding weight. DMFC is also cost competitive with long run-time Li-ion batteries.

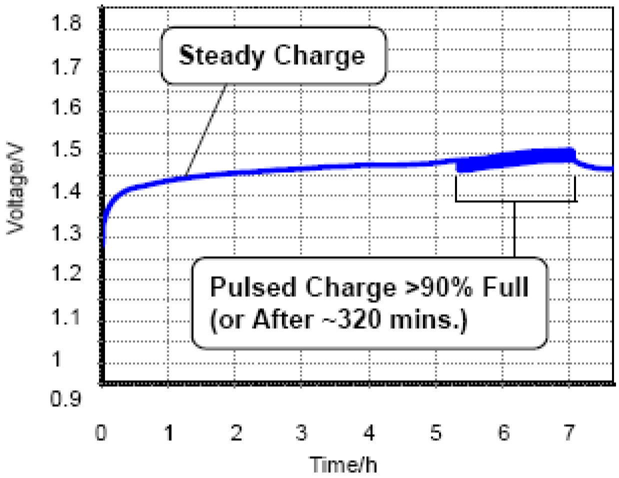
While DMFCs are very efficient at providing power over an extended period of time, currently available DMFC technology is not very good at providing high power demands. For this reason, DMFCs likely will not replace traditional battery technology but will be coupled with Li-ion battery technology in a hybrid approach where DMFC used for devices requiring long run-times with low power demand and Li-ion battery for devices with short run-times and high power demand. By coupling these two technologies, DMFCs can provide average power amount to the device while the Li-ion battery provides the spikes in power demand (e.g. when a mobile phone sends a call or a laptop boots up). When the device is operating at less than the average energy consumption, the DMFC can use excess power to recharge Li-ion battery.

Using DMFCs will result in substantially small and light portable power solution compared to a Li-ion only device. Further, the absence of heavy metals in DMFCs suggest them an improved alternative over disposal batteries entering the waste stream.

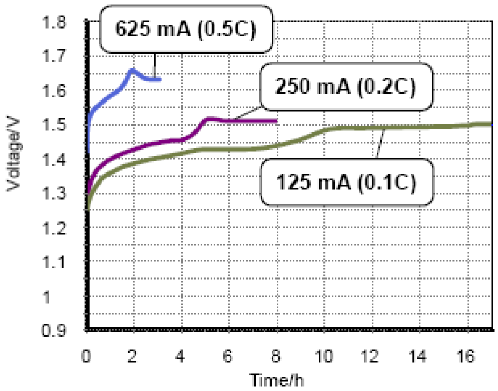
6.6.2 USB CHARGED BATTERIES

These traditionally AA looking batteries have a USB connector integrated in the battery itself and thus can be charged by plugging them directly to the USB port of a computer. Currently commercialised under the name USBCELL, it contains a Ni-MH battery but currently expensively priced (around 20 euros) and their success in the future will depend on the price cut down and the charging period. Following are the charging characteristics:

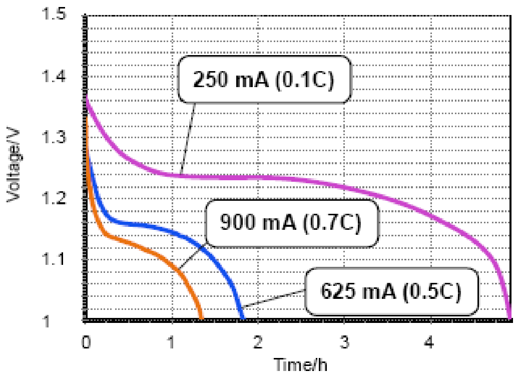
Typical Charge via USB:



Typical Charge Characteristics:



Typical Discharge Characteristics:



6.7. CONCLUSIONS

Power supply industry is moving forward with a great pace, improving current technologies and introducing new approaches. Requirements set by portability have been driving the EPS and BC sizes down, calling for more efficient power supply technologies. Another important driver for technology development in this sector are the minimum energy efficiency standards and legislation which have recently been drafted also for EPS e.g. in California and Australia. Further, innovative approaches and manufacturing processes are enabling the production of new components and products cost-effectively. Such developments are happening both at the component and product level which may not always be linked.

The principal developments aim at increasing energy efficiency, low no-load consumption, and miniaturisation. However, sometimes a trade-off has been observed between the energy efficiency and standby consumption, as some innovative EPS designed for very low standby/off-mode losses do not target very high efficiency levels, and vice versa. Many of the state-of-the-art products and components rely on patented technologies. However, they are often based on common improvement approaches, such as:

- Switch-mode power conversion
- Integrated IC
- Efficient transistors (e.g. MOSFET)
- Resonant switching
- Synchronous power rectification
- Flyback and half-bridge topologies for high output power applications

Further innovations are expected, although information on the long-term visions of the EPS and BC manufacturers is scarce. In the short- to mid-term, solar power supplies and chargers are likely to replace at least a part of the EPS and BC stock.

These approaches will be analysed from a product perspective in Task 7 when the cost of implementing BAT and the benefits achieved (reduction of environmental impacts) will be evaluated.

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7. IMPROVEMENT OPTIONS

Task 7 consists of identifying the design improvement options, quantifying the influence they have on environmental impacts and monetising them in terms of Life Cycle Costs (LCC) for the consumer. Finally, one or more solutions of Best Available Technology (BAT) and with least life cycle cost (LLCC) needs to be identified.

Key technical improvement options have been identified on the basis of technology development and research as listed in task 6. Such option are described in the following sub-sections, listing their environmental improvement potential, feasibility for different applications, and associated costs. Looking at the wide variety of products being addressed in the lot 7 and a large set of improvements possible at product and/or component level, it will not be feasible to quantify all the improvement options. Hence, the quantitative analysis will focus on selected key options and LLCC calculations will include the base-cases to which these options are applicable. However, all the identified options will be analysed and discussed in detail to highlight their significance.

The Task 7 document is structured as follows:

- Section 7.1 presents the assessment of individual improvement options: the product range for which an option is applicable, its impacts on the Bill of Materials, possible environmental improvements using this option, life cycle cost implications, and other possible constraints.
- Section 7.2 analyses LLCC and BAT
- Section 7.3 discusses long-term targets (BNAT) and potential on the basis of changes of the total system.

7.1. OPTIONS

Principle improvement options tackle aspects on the level of materials and components and on the level of circuitry layout / control principles, among them aspects, which correlate with the concept of digital power control, which "offers the hope that core digital control will mean better control for optimized efficiency for all operating conditions by possibly including full I/O-power monitoring, multiple-topology operation, power-optimization control, the need for fewer converters through the use of an alternative architectural structure, and the elimination of redundancy."[1]

1 A. Alderman: Global Report 3: Surfing for market share? Ride the efficiency wave, Government agencies are joining utility companies to reduce power consumption by targeting inefficient power supplies, EDN, 11/9/2006

Furthermore, there are additional options to address lifetime extension and user behaviour. Following is the list of improvement options analysed in subsequent sub-sections:

- Linear-mode technology
  - Toroidal transformers instead of EI-core transformers
- Technology conversion
  - Replacing linear technology with switch-mode technology
  - Change from magnetic transformers to electronic transformers (transformers for halogen lighting)
- Switch-mode technology
  - Primary integrated IC
  - Schottky diodes
  - Resonant / Quasi-resonant switching
  - Synchronous power rectification
- Switch-mode technology with power factor correction
  - Active and Quasi-active PFC
  - PFC switch-off in low load
  - Single-stage flyback topology for EPS with PFC
- Battery chargers: microprocessor controlled charging
- Lifetime extension, multiple use, and reuse
- Consumer behaviour: reduction of no-load times

7.1.1 TOROIDAL TRANSFORMERS INSTEAD OF EI-CORE TRANSFORMERS

Relevant product range

In general, linear transformers are used in low power range external power supplies. An example of the application of linear transformers is AC-AC EPS for cordless phones as the switch-mode technology is much more complicated for simply stepping down the voltage[2].

Toroidal transformers, as an alternative to EI-core transformers, have traditionally been used only for higher power output ranges. However, this concept can also be applied to the low power range as proposed recently by PanPower (see section 6.3).

[2] However, a principle alternative to AC-AC external power supplies with rectification in the end-device is an AC-DC power supply with integrated rectification

For halogen lighting there are toroidal transformers on the market, competing with EI-core transformers, but the former are mainly used for the ceiling installations, where the cylindrical form covers the cable outlet for the lighting.

Effects on Bill of Materials

For halogen lighting, the weight comparison of transformers currently on the market (see task 4) does not show any significant weight difference between EI-core and toroidal transformers. As the materials for both of them are basically the same, the effects on the BOM in terms of materials are negligible.

Environmental impacts

In the segment of halogen lighting transformers, the toroidal design is linked to a higher efficiency than for EI-core design – the difference being in the range of several percent. Due to the long life (and use time) of halogen lighting transformers, the effects of such a change over the product life cycle could be significant. For example, for a 60 W transformer, an increased efficiency of 5%, (reasonable for toroidal transformers compared to EI-core transformers) translates into electricity savings of roughly 87.6 kWh[3].

However, compared to electronic transformers (see section 7.1.3), toroidal ones are usually less efficient and significantly more material consuming.

Cost effects

The toroidal transformer for low output range is still at the prototype level and has not been introduced in mass production yet. Hence, it is difficult to estimate the potential cost effects. However, fast processing has been demonstrated by PanPower and material costs are assumed to make the main difference compared to EI-core transformers. As the toroidal transformer requires less steel for the core and less copper for the windings – both of which are currently dominating cost factors for linear power supplies – it can be assumed that the toroidal transformer could be significantly cheaper if manufactured in high volumes.

For improvements beyond Energy Star performance criteria, a high-grade steel is required, which is approximately four times more expensive than standard steel, making such an option a significantly more expensive, roughly 1.5 to 2 times compared to a toroidal transformer with standard grade steel core.

For halogen lighting transformers, the power savings at 5% efficiency increase sum up to 11.90€ for the consumer[4] compared to a 20 € purchase price advantage for EI-core transformers in the 60 W segment (see task 2 for a detailed graph[5]).

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3 assuming use time of 8h per day for 10-year lifetime

4 at 0.136 Euro/kWh

5 This price difference is evident in the market dominating range up to 105 VA, making toroidal transformers currently not a more economic alternative for the consumer

■ **Constraints / limitations**

The manufacturing technology for low power toroidal transformers is intellectual property of PanPower, although their policy is to keep the patented manufacturing method open to anyone who is interested in it. However, their design is still in pre-manufacturing stage and the costs of using this patented design are not known.

For halogen lighting, due to the high power requirements, magnetic transformers are bulky, and for many mounting tasks a brick-like shape may be preferable or even the only possible solution and cylindrical toroidal units may not be a feasible option.

7.1.2 REPLACING LINEAR TECHNOLOGY BY SWITCH-MODE TECHNOLOGY

As switch-mode technology is already dominating on the market, a market wide change from linear to switch-mode power supplies does not require a redesign of external power supplies as such, as suitable EPS are already available for common power ranges. However, such a change may necessitate a modification in the design of the end-application, especially in the case where a linear AC-AC power supply has to be replaced by a switch-mode AC-DC unit.

■ **Relevant product range**

The change from linear to switch-mode power supplies is an important issue for the low power output range (see the discussion on the cost break-even point in task 2). Most likely there are no linear battery chargers with an output power of more than 25 W on the market, and no external power supplies with linear transformer above 20 W.

Few products run fully on AC, such as fairy lights, for which a change from AC-AC to AC-DC switch-mode units does not make sense.

A separate section (7.1.3) deals with the comparison of linear and switch-mode, for high power range such as halogen lighting transformers.

■ **Effects on Bill of Materials**

<u>Change from linear to switch-mode "only"</u>

Table 7-1 below compares the resource consumption in the production phase[6] for two mobile phone EPS from the same manufacturer, one using linear design and another switch-mode. The amount of electronics components is higher for switch-mode designs. But, due to the bulkiness of the linear designs, the SMPS contain much less "electronics" in terms of weight.

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6 Data entries for cables have been set the same as this is not correlated with the transformer technology. The exemplary linear power supply provides slightly smaller output wattage than the switch-mode one, which consequently means that the advantage of switch-mode EPS actually is rather higher than what is demonstrated here.

The energy consumption in the production of a SMPS is calculated to be one third of that for a linear EPS. The greenhouse gas emissions show the same trend. For all emissions (to air and water) the switch-mode design results in significantly lower values in all categories.

Table 7-1 – Production phase comparison of linear and switch-mode EPS

			linear EPS (mobile phone)			switch-mode EPS (mobile phone)			ratio SMPS : linear
	Life Cycle phases -->		PRODUCTION			PRODUCTION			
	Resources Use and Emissions		Material	Manuf.	**Total**	Material	Manuf.	**Total**	
	Materials	**unit**							
1	Bulk Plastics	g			**23**			**23**	100,0%
2	TecPlastics	g			**31**			**26**	84,3%
3	Ferro	g			**1**			**2**	119,9%
4	Non-ferro	g			**18**			**19**	108,2%
5	Coating	g			**0**			**0**	n.a.
6	Electronics	g			**105**			**20**	19,0%
7	Misc.	g			**10**			**10**	100,0%
	Total weight	g			**188**			**100**	53,2%
	Other Resources & Waste								
8	Total Energy (GE	MJ	49	16	**64**	16	4	**21**	32,2%
9	of which, electri	MJ	3	2	**5**	5	1	**6**	131,4%
10	Water (process	ltr	6	1	**7**	5	0	**5**	68,2%
11	Water (cooling)	ltr	11	4	**15**	6	1	**7**	46,5%
12	Waste, non-haz	g	353	18	**372**	311	8	**319**	86,0%
13	Waste, hazardo	g	5	0	**5**	8	0	**8**	165,5%
	Emissions (Air)								
14	Greenhouse Ga	kg CO2 eq.	3	1	**4**	1	0	**1**	31,0%
16	Acidification, em	g SO2 eq.	22	6	**27**	11	1	**13**	46,5%
17	Volatile Organic	g	0	0	**0**	0	0	**0**	18,5%
18	Persistent Orga	ng i-Teq	0	0	**0**	0	0	**0**	64,8%
19	Heavy Metals	mg Ni eq.	2	0	**3**	2	0	**2**	93,6%
	PAHs	mg Ni eq.	21	0	**21**	3	0	**3**	12,6%
20	Particulate Matte	g	4	2	**6**	1	0	**1**	21,1%
	Emissions (Water)								
21	Heavy Metals	mg Hg/20	9	0	**9**	3	0	**3**	27,8%
22	Eutrophication	g PO4	0	0	**0**	0	0	**0**	62,1%

General differentiation among the switch-mode power supply market

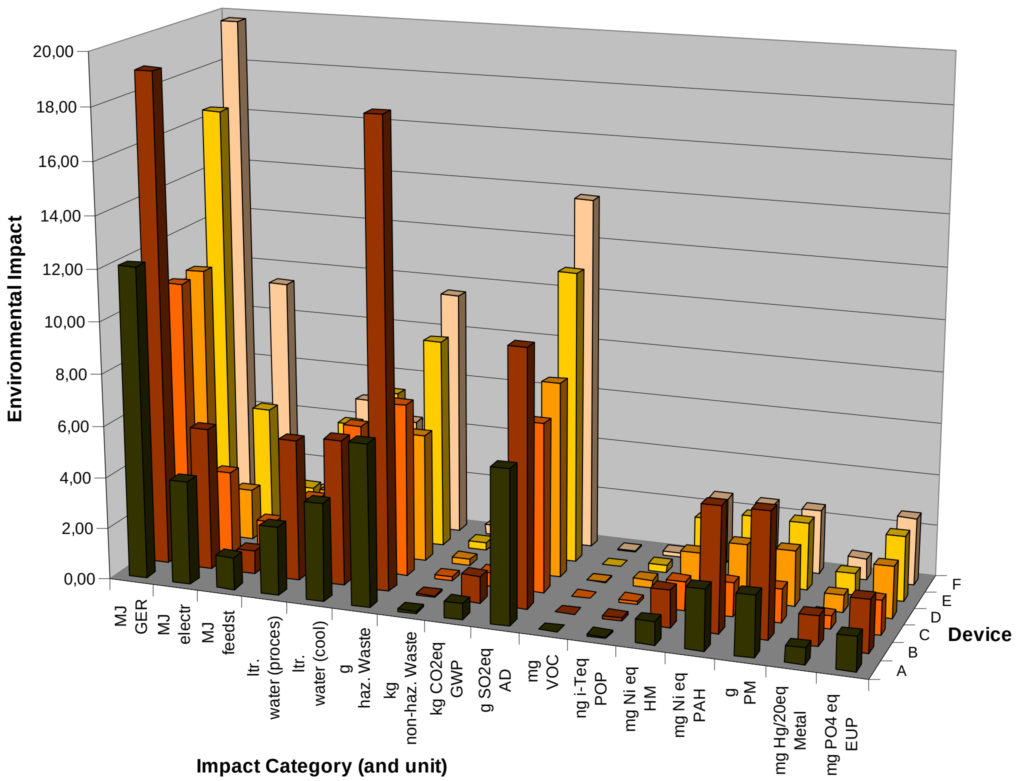
Even among switch-mode designs, the Bill-of-Materials can vary widely in a given market segment. This depends on several technical aspects, such as

- **Circuit layout**, including specific measures such as resonant / quasi-resonant switching, primary-side controlled units
- **Level of integration:** replacement of discrete components by integration in an ASIC which results in less components and overall smaller size
- **Assembly technology**: THT and/or SMT, the latter allows to use smaller (but usually more costly) components

These technical changes not only affect the BOM, but also the results of the Environmental Impact Assessment of the production phase of the life cycle.

Figure 7-1 below shows the environmental impacts evaluation of 6 external power supplies for mobile phones (i.e. low power range < 5 W)[7].

Figure 7-1 –Production phase environmental impacts for different switch-mode EPS for mobile phones[8]



The Figure 7-1 shows that design decisions at the BOM and circuit layout level influence the environmental impacts during the production phase significantly. In some categories the worst EPS shows **3.5 times higher environmental impacts** compared to the best one. For **primary energy consumption**, the result for the worst EPS is **90% higher** than that of the best performing one[9].

The external power supplies with lower environmental impacts in the production phase usually also cause a lower impact in the use phase (low no-load losses and high efficiency), which leads to the conclusion that low impact in production and low impact in the use phase are not contradictory to each other but rather

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7 Significant differences among the different switch-mode power supplies can also be observed for end-of-life, but for illustration, this graph only covers the production phase

8 While interpreting these results one should be aware that the MEEUP methodology is not intended to be used for comparisons of individual products and that there are uncertainties in the methodology, which are negligible for the general assessment of the overall market but might be misleading on the level of individual products (e.g. sub-categories for electronic components, where the sub-categories include already a mix of real-world components, which are partly not contained in the device under consideration)

9 In some categories the copper from cables make up a significant part of the differences, rather than the electronic circuitry and related effects (e.g. on housing size)

complementary[10]. However, there seems to be one exception: the entry "Big caps & coils" has, for a couple of base-cases, a significant environmental impact, but to reduce the size of coils and transformers among switch-mode power supplies would mean new requirements regarding safety and other electrical aspects. Reducing the size of the coils would also mean lower efficiency as the switching frequency would have to be increased[11].

In Figure 7-1 a detailed exemplary comparison is given for mobile phone EPSs only, but similar variations are very likely within other market segments as well. An indication for this assumption is the fact, that the weight of EPS with similar functionality differs remarkably.

A conservative estimate leads to the assumption that **10% improvement in production related primary energy consumption** is feasible throughout the whole external (switch-mode) power supply market.

Environmental impacts

In general, the linear EPS have lower efficiency and higher no-load losses than switch-mode ones. Furthermore, the linear EPS require more material for the coils, whereas switch-mode supplies have a higher number of electronic components (see the previous sub-section).

Cost effects

As discussed in correlation with the market analysis (task 2), the break-even point (production costs) of linear and switch-mode supplies has already shifted to the low power range. Depending on the conditions in different low power market segments, there might be a small production cost benefit either for linear or SMPS. A research on manufacturers in China and Taiwan came to the conclusion that switch-mode EPS might be up to 5–10 percent costlier than the linear ones[12]. A 5% cost increase for the low power range would mean

- + 0.32 € for power supplies in the range of 5–10 W (e.g. set-top box base case)
- + 0.17 € for power supplies in the range up to 5 W (e.g. mobile phone, cordless phone, personal care products base cases)

For comparison, this equals to power savings of 2.5 kWh and 1.3 kWh respectively.

---

10 This corresponds to the technical basics, e.g. a high level of integration usually comes with reduced losses compared to discrete components

11 For the change from linear to SMPS the general design recommendation to reduce "big caps & coils" which actually is a direct effect of this change of course is beneficial for both BOM impacts and efficiency

12 A. Rosenfeld at Committee Workshop before the California Energy Resources Conservation and Development Commission in the matter of: Appliance Standards for External Power Supplies and Other Consumer Electronic Products, Sacramento (CA), January 30, 2006

Taking the system perspective into account, M. Ellis in preparation of the Australian regulations stated,[13] "Typically, switch-mode type power supplies are more expensive than linear power supplies. However, when considering all the costs involved, the difference may be negligible. For example, most linear adapters are non-regulated so many portable devices use an additional input regulator; whereas using a regulated switching power supply with build-in protection simplifies design and lowers the overall cost."

- **Constraints / limitations**

Switch-mode EPS can meet the required specifications for almost all AC-DC applications. Only for stationary audio products (which are operated while the EPS is plugged in, (i.e. not for portable ones which run basically on the battery power), the linear design provides a significant advantage as it allows to minimise electro-magnetic interference. With SMPS there might be noise disturbances in amplifiers caused by the switching of the SMPS[14]. However, this effect can be minimised through appropriate configuration[15]. Furthermore, the market segment of audio equipment being powered by EPS in active mode is assumed to be very small[16].

7.1.3 HALOGEN LIGHTING: CHANGE FROM MAGNETIC TO ELECTRONIC TRANSFORMERS

- **Relevant product range**

Electronic transformers are an alternative to magnetic transformers for the full range of halogen lighting transformers.

- **Effects on Bill of Materials**

The Bill-of-Materials changes significantly as the weight for electronic transformers is much lower, though the number of electronic components is higher. Comparing the BOM effects on the production phase (similar tendencies for end-of-life), the electronic transformers shows a clear advantage in all impact categories as shown in Table 7-2. Total energy consumption in the production phase drops to 15.1%, process water consumption drops to 23.3%, waste generation for electronic transformers is approximately half the amount for magnetic transformers, etc. The comparison given here is for a 60 W transformer, but as there is a linear correlation between weight (similar to BOM effects) and output power for both magnetic and electronic transformers, the relations are going to be same for other power ranges.

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13 M. Ellis & Associates: Analysis of Potential for Minimum Energy Performance Standards – External Power Supplies, prepared for The Australian Greenhouse Office and NAEEEC under the National Appliance & Equipment Energy Efficiency Programme, Draft Final Report, October 2004

14 D. Campbell at Committee Workshop before the California Energy Resources Conservation and Development Commission in the matter of: Appliance Standards for External Power Supplies and Other Consumer Electronic Products, Sacramento (CA), January 30, 2006

15 D. Campbell: "the external power supplies we sell now need additional information to the consumer on what the consumer needs to do to minimize interference."

16 Dedicated market data for this segment is not available.

Table 7-2 – Production phase comparison of magnetic and electronic transformers

			magnetic transformer			electronic transformer			ratio electronic : magnetic
	Life Cycle phases -->		PRODUCTION			PRODUCTION			
	Resources Use and Emissions		Material	Manuf.	**Total**	Material	Manuf.	**Total**	
	Materials	**unit**							
1	Bulk Plastics	g			**60**			**30**	**50,0%**
2	TecPlastics	g			**200**			**0**	**0,0%**
3	Ferro	g			**0**			**0**	**n.a.**
4	Non-ferro	g			**0**			**66**	**n.a.**
5	Coating	g			**0**			**0**	**n.a.**
6	Electronics	g			**990**			**127**	**12,8%**
7	Misc.	g			**15**			**5**	**33,3%**
	Total weight	g			**1265**			**228**	**18,0%**
	Other Resources & Waste								
8	Total Energy (GE	MJ	410	138	**548**	65	18	**83**	**15,1%**
9	of which, electri	MJ	9	10	**19**	8	2	**10**	**50,1%**
10	Water (process	ltr	42	12	**54**	11	1	**13**	**23,3%**
11	Water (cooling)	ltr	143	38	**181**	12	5	**17**	**9,3%**
12	Waste, non-haz	g	731	139	**870**	378	23	**401**	**46,0%**
13	Waste, hazardo	g	67	4	**71**	37	1	**37**	**52,3%**
	Emissions (Air)								
14	Greenhouse Ga	kg CO2 eq.	23	9	**32**	4	1	**5**	**14,9%**
16	Acidification, em	g SO2 eq.	152	51	**203**	29	6	**35**	**17,4%**
17	Volatile Organic	g	0	3	**3**	0	0	**0**	**13,3%**
18	Persistent Orgar	ng i-Teq	2	0	**2**	1	0	**1**	**37,8%**
19	Heavy Metals	mg Ni eq.	8	1	**9**	3	1	**4**	**38,1%**
	PAHs	mg Ni eq.	197	3	**199**	27	0	**27**	**13,6%**
20	Particulate Matte	g	38	15	**53**	5	2	**7**	**13,1%**
	Emissions (Water)								
21	Heavy Metals	mg Hg/20	72	0	**72**	10	0	**10**	**14,1%**
22	Eutrophication	g PO4	2	1	**3**	0	0	**0**	**7,7%**

Environmental impacts

The principle change from magnetic to electronic transformers basically is a question of higher efficiencies and drastically reduced weight and size.

The power consumption of electronic transformers is significantly lower than for magnetic transformers: 92.5% market average efficiency of electronic transformers is a significant improvement compared to the 80% market average in the range up to 60 W. For the exemplary 60 W lamp load transformer, this difference means a reduction of more than 10 W power input to the transformer which amounts to roughly 300 kWh for a single transformer over its lifetime. Also in case no-load losses matter (secondary side switched transformers), electronic transformers perform much better than magnetic transformers: For an exemplary 60 W transformer, no-load losses of a magnetic design are in the range of 4 W typically compared to 0;2 W for an electronic transformer.

However, magnetic transformers are more robust. The shorter lifetime of electronic transformers matters especially for halogen lighting systems, which are intended to be used for several years. With lifetimes of 50,000 hours for electronic transformers compared to 100,000 hours for magnetic ones[17] means a worst case limitation of 5.5 years (for always on lighting) lifetime, which is below the expected lifetime for such lighting systems, specially in case of installations. Furthermore, in case the transformer has to be mounted in places which are difficult to access (ceiling integrated, for example) the replacement of a failed device is severely hindered.

Cost effects

Average electronic transformers compared to magnetic transformers result in electricity savings worth of 30 € over the lifetime[18]. For a scenario with a secondary side switch (considering no-load losses), this difference totals in 55 €. As electronic transformers are less expensive than magnetic ones, the life cycle costs are lower in any case.

Assuming the transformers are in use for 100000 hours, which actually means two electronic transformers are required against one magnetic transformer (worst case for the electronic transformer)[19], the lifecycle costing for a 60 W lamp load transformer is as follows (labour costs for replacement by a technician are <u>not</u> included):

	magnetic	electronic
Use scenario	100000 hours in use	
No. of units required	1	2
Product price (based on average market price for 60 W transformers)	20 €	2 times 20 €
Energy savings (92.5 % efficiency compared to 80 %)	-	1014 kWh
Electricity cost savings (at 0.136 €/kWh)	-	- 138 €
Life cycle cost comparison	20 €	- 98 €

The life cycle cost difference of these two options is 118 € per 100000 hours of lamp (and transformer) operation. Even if one takes into account the service costs of replacing the electronic transformer after 50000 hours of use, there is a clear LCC benefit by using an electronic transformer.

17 See for example Tridonic: English catalogue 2006/2007, Transformers for low-voltage halogen lamps

18 For comparison: for a minimalist use profile of 5 years lifetime and only 2 hours use daily the savings in electricity are still in the range of 5 € in total (at 0.136 €/kWh)

19 Actually the scenario of 10 years 8 hour use annually corresponds to 29200 hours operation, compared to 50000 hours average lifetime of electronic and 100000 hours average lifetime of magnetic transformers

Constraints / limitations

Besides lifetime issues there are no major constraints regarding electronic transformers.

7.1.4 PRIMARY INTEGRATED IC

As outlined in task 6, several power supply and component manufacturers in the recent past followed the use of primary integrated circuits, for example FRIWO, iWatt, and Power Integrations.

Relevant product range

Most primary integrated ICs are designed for the low power range (see task 6), typically mobile phone chargers up to 5 W, but the approach is also feasible for higher power ranges, such as for laptop applications[20].

Effects on Bill of Materials

Primary-side regulation results in a significant reduction in the number of electronic components. A relevant BOM is provided in task 6.

For high power ranges, such as laptops (65 W, without PFC), the size of the printed circuit board (and the amount of components accordingly) can be reduced by approximately 20%[21].

Environmental impacts

In summary, following achievable power consumptions (no-load and average efficiency) are stated by the manufacturers:

	3 W	5 W
FRIWO	<100 mW / 64%	<200 mW / 67%
iWatt	"CEC/EPA compliance", i.e. minimum: 500 mW / 58.8%	"CEC/EPA compliance", i.e. minimum: 500 mW / 63.5%
Power Integrations (reference design[22])	<30 mW / 61.5% (EPR-84)	<100 mW / 71.5% (DER-113)

20 M. Bothe: Effizienzanforderungen an externe Stromversorgungen, 8. Treffen AK Richtlinien-konformes Design für WEEE, RoHS und EuP, Berlin, June 13, 2006

21 M. Bothe: Effizienzanforderungen an externe Stromversorgungen, 8. Treffen AK Richtlinien-konformes Design für WEEE, RoHS und EuP, Berlin, June 13, 2006

22 www.powerint.com/appcircuits.htm

Cost effects

Costs of EPS with primary integrated IC are competitive and demonstrated by the fact that these are frequently used in the highly competitive market segment of mobile phones[23]. The reduced number of electronic components even leads to reduced BOM costs.

Constraints / limitations

The primary regulation as realised by FRIWO is based on a patented technology using an ASIC developed by FRIWO. However, at least iWatt and PI also manufacture ICs for this technology

7.1.5 SCHOTTKY DIODES

Relevant product range

Schottky diodes are frequently used as output rectification for medium to high power density switch-mode designs. However, efficiency of diodes is relevant for all EPS, not only switched-mode designs but also linear ones. Schottky diodes can also be used for electronic transformers for lighting applications.

Effects on Bill of Materials

The BOM in terms of component classes and weights does not change significantly when using Schottky diodes instead of conventional ones.

Environmental impacts

A main characteristic of diodes is the forward voltage drop, which is in the range of 0.7 V for conventional diodes and 0.2 V for Schottky diodes. At the secondary side of switched-mode power supplies, where the voltage is low but current is high, a high voltage drop means significant efficiency losses.

Depending on the current at the secondary side of the power supply, the efficiency losses of the diodes can be up to a few Watts, which can be reduced by using Schottky diodes.

For electronic transformers for lighting applications in the medium power range, power losses can be reduced by approximately 10% using Schottky diodes and more efficient transistors[24].

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23 FRIWO claims, that no-load losses of 100 and 200 mW respectively are achievable with primary integrated ICs without additional costs. Lower no-load losses seem to be achievable only with increased BOM costs (M. Bothe, personal communication)

24 Soraluck Noitachang, ASIFaCT workshop, Penang, Nov 6-17, 2006

- **Cost effects**

Schottky diodes are more costly than conventional ones but in case of electronic transformers it is assumed that the payback period is quite reasonable[25].

- **Constraints / limitations**

Besides the BOM cost issue there are no further constraints. Schottky diodes are available on the market from a large number of component manufacturers.

7.1.6 SYNCHRONOUS RECTIFICATION

In a switch-mode EPS, the output rectification on the secondary side can be the dominant loss component. The main reason is the higher current on the output side than on the input side (at lower voltage). Depending on the technical inherent voltage drop across the switches significant efficiency losses result. A technology to minimise these losses on the secondary side is synchronous power rectification.

- **Relevant product range**

Synchronous rectification is a technical option for external SMPS in general, from the low power segment to the laptop segment. For the latter, for example International Rectifier provides MOSFETs for synchronous rectification.

- **Effects on Bill of Materials**

Synchronous power rectification can be realised without major changes in the BOM. As a benefit, the switching transistors do not need heat sinks as the losses are reduced.

- **Environmental impacts**

Reducing the losses in the rectification stage results in an overall increase in efficiency. As outlined in task 6, a BAT prototype has been realised for 5 W power output, which achieves an average efficiency of 83.5 %[26]. No-load losses tend to increase but the prototype nevertheless achieves less than 0.15 W no-load losses.

- **Cost effects**

Synchronous power rectification makes the EPS more costly but the cost impact is difficult to quantify. The benefit and the reason why such a concept is going to

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25 S. Noitachang assumed a payback period for lighting equipment of one year – based on 8 hours use daily.

26 This prototype is realised in conjunction with a primary-side control IC. As an orientation: The product generation before with “primary integrated IC only” achieved an average efficiency of 67% (M. Bothe: Die Menge macht’s – Energie-Effizienz von Klein-Stromversorgungen, Elektronik, Ecodesign 2006)

be implemented under current market conditions is the fact that this technology provides high currents and allows faster charging of batteries.

For the consumer, the increased efficiencies and still low no-load losses means electricity costs savings.

- **Constraints / limitations**

The concept of synchronous rectification is a replacement for diodes in the rectification stage, which might have been realised with Schottky diodes as described above. Hence, these two concepts can be seen as alternatives rather than complementary.

7.1.7 RESONANT / QUASI-RESONANT SWITCHING

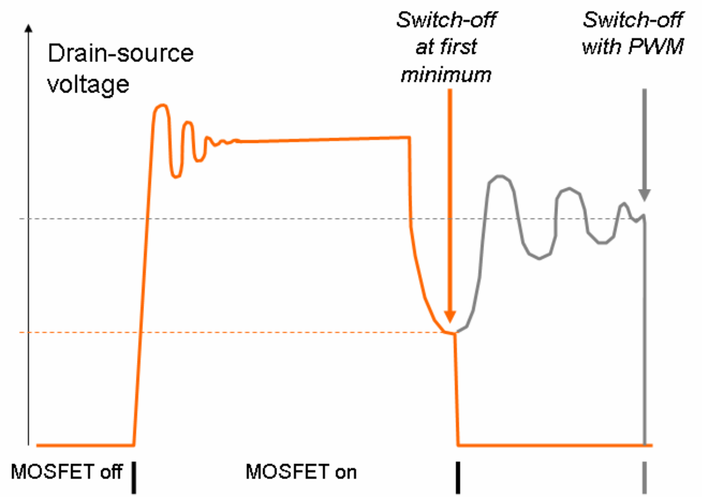
A major reason for efficiency losses in SMPS are switching losses. Resonant switching allows reducing these losses by switching while either the voltage or the current wave is at a minimum. Resonant switching is an alternative to pulse-width modulation (PWM) switching techniques. PWM requires the power semiconductor to turn on and off the entire load current during each switching cycle, resulting in switching losses which are directly correlated with the switching frequency.

These conversion techniques include[27]

- Zero current switching
- Zero voltage switching
- Soft switching and phase controlled resonant inverters
- Quasi-resonant fly-back and push-pull inverters

27 EPRI Solutions, Ecos Consulting: Designing Ac-Dc Power Supplies for Improved Energy Efficiency: A Technical Primer, December 2004

Figure 7-2 – Quasi-resonant switching: MOSFET is switched off at first minimum of drain-source voltage[28]



Relevant Product Range

Resonant and quasi-resonant switching are relevant for switch-mode power supplies in general.

Effects on Bill-of Materials

The BOM requires some additional electronic components, which are needed for the resonance that causes the reshaping of the waveform to allow switching at zero voltage or zero current.

Environmental impacts

The efficiency of resonant and quasi-resonant designs compared to PWM designs is higher for high switching frequencies (but might be lower at low switching frequencies). Consequently, it cannot be concluded, that resonant and quasi-resonant switching is more efficient per se. EPS design has to take this into account. EPRI and Ecos state an achievable efficiency of 75–95% using such designs.

Cost effects

EPRI and Ecos state higher manufacturing costs for resonant and quasi-resonant designs, though detailed figures are not mentioned[29].

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28 Adapted from: J. L. Small, C. Walding: Grünes Licht für “Going Green”, Elektronik, Ecodesign 2006

29 EPRI Solutions, Ecos Consulting: Designing Ac-Dc Power Supplies for Improved Energy Efficiency: A Technical Primer, December 2004

- **Constraints / limitations**

Some of the resonant and quasi-resonant switching techniques are patented but a range of leading component suppliers provide such ICs[30] and these options are implemented already in a number of available products.

7.1.8 ACTIVE AND QUASI-ACTIVE POWER FACTOR CORRECTION

The two principle options for power factor correction are active PFC and passive PFC (see also System Analysis in task 4). Actually there is a huge number of dedicated active PFC control techniques (see Rustom and Batarseh for an overview[31]). A quasi-active PFC concept has been proposed to overcome same of the problems with active PFC[32].

- **Relevant product range**

As PFC is required only for devices with more than 75 W input, so this technical option is relevant for high power output range.

- **Effects on Bill of Materials**

Active PFC operates with higher switching frequencies, which allows using much smaller passive components.

- **Environmental impacts**

There are contradictory environmental impacts of passive and active PFC stages: The components used for passive PFC are normally bulky and heavy[33] and thus are contributing to the high resource consumption during production. On the other hand, the overall power-conversion efficiency is lower due to the additional switching stage. In no-load, the active PFC stage tends to consume more power than a power supply design with passive PFC.

- **Cost effects**

Although the total component weight of active PFC designs is lower, the BOM costs are assumed to be higher.

- **Constraints / limitations**

As there are a huge number of designs available for active PFC, there are no major constraints, but overall electronic layout has to care for optimum results in terms of environmental improvements.

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30 E.g. Sanken Power Devices

31 K. Rustom, I. Batarseh: Recent Advances in Single-stage Power Factor Correction, ICIT 2003, Maribor, Slovenia

32 J. G. Zhang: Low-Cost PFC Design Meets Regulatory Standards, Power Electronics Technology, August 2005

33 J. L. Small, C. Walding: Grünes Licht für “Going Green”, Elektronik, Ecodesign 2006

7.1.9 POWER FACTOR CORRECTION SWITCH-OFF IN LOW LOAD

To reduce the power consumption under low load and no-load, where no power factor correction is needed, the PFC stage can be switched off.

Relevant product range

As PFC is required only for devices with more than 75 W input so this is the power range for which this technical option is relevant.

Effects on Bill of Materials

To switch off the PFC stages requires additional control, which adds to the Bill of Materials.

Environmental impacts

PFC switch-off in low load is a measure among others, implemented by several manufacturers to comply with the mandatory standards in California (**0.75 W no-load** losses).

The environmental impacts for a 90 W power supply unit with PFC switch-off at low and no-load are given in the following table.

Table 7-3 – EIA for a 90 W EPS with reduced no-load losses of 0.75 W

	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			**51**			46	5	**51**	**0**
2	TecPlastics	g			**73**			66	7	**73**	**0**
3	Ferro	g			**3**			0	3	**3**	**0**
4	Non-ferro	g			**93**			5	88	**93**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**176**			90	86	**176**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**396**			206	190	**396**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	90	28	**118**	**52**	**2940**	15	18	**-3**	**3107**
9	of which, electricity (in primary MJ)	MJ	11	4	**15**	**0**	**2939**	0	10	**-10**	**2944**
10	Water (process)	ltr	13	2	**15**	**0**	**196**	0	9	**-9**	**202**
11	Water (cooling)	ltr	24	8	**31**	**0**	**7837**	0	2	**-2**	**7866**
12	Waste, non-haz./ landfill	g	1355	39	**1394**	**52**	**3421**	25	29	**-4**	**4863**
13	Waste, hazardous/ incinerated	g	29	1	**30**	**1**	**68**	198	11	**186**	**285**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	5	2	**7**	**5**	**128**	1	1	**0**	**140**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	49	10	**59**	**12**	**757**	2	8	**-6**	**823**
17	Volatile Organic Compounds (VOC)	g	0	1	**1**	**0**	**1**	0	0	**0**	**2**
18	Persistent Organic Pollutants (POP)	ng i-Teq	1	0	**1**	**0**	**19**	0	0	**0**	**21**
19	Heavy Metals	mg Ni eq.	7	0	**8**	**3**	**50**	4	1	**3**	**64**
	PAHs	mg Ni eq.	32	0	**32**	**3**	**6**	0	1	**-1**	**40**
20	Particulate Matter (PM, dust)	g	7	3	**9**	**2**	**16**	19	0	**19**	**46**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	18	0	**18**	**0**	**19**	1	6	**-5**	**32**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

- **Cost effects**

PFC switch-off is more costly, but as demonstrated by the fact that it is already introduced in the market (however mainly for compliance reasons), the additional product costs to implement this option seem to be minor.

- **Constraints / limitations**

PFC switch-off in low mode can be considered a mature technology.

7.1.10 SINGLE-STAGE FLYBACK TOPOLOGY FOR EPS WITH PFC

Single stage PFC can reduce the BOM significantly.

- **Relevant product range**

The main target segment for single-stage power supplies with PFC is the (laptop) segment above 65 W output power.

- **Effects on Bill of Materials**

Consecutive PFC stage and main power transformation requires also two magnetic elements, two controllers, two FETs. The single-stage solution comes with a significant reduction in components. It can be assumed that this also results in a smaller overall printed circuit board design meaning a further size reduction of the housing. Consequently, a clear reduction in environmental impacts resulting from the materials extraction and production phase as well as from the manufacturing stage, corresponding closely also with the impacts at end-of-life can be assumed. The order of magnitude of achievable improvements in these three phases is estimated at 20%[34].

- **Environmental impacts**

Based on the data provided by ON Semiconductor / Energy Recovery Systems Corporation and iWatt (see task 6) on single-stage topologies for power factor corrected power supplies, it is concluded that in principle **average efficiencies of 87%** coupled with low no-load losses are achievable at 230 V AC input.

- **Cost effects**

ON Semiconductor claims a cost reduction for their given design by “over 20%”, being closely related to the significantly reduced number of components.

- **Constraints / limitations**

There are dedicated solution providers offering components for this layout.

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[34] As component-count related weight reductions for transformers/coils and the printed circuit board can be realised.

7.1.11 BATTERY CHARGERS: MICROPROCESSOR CONTROLLED CHARGING

Microprocessor controlled charging allows an adaptation of the charging cycle to the specific charging status of the battery pack(s), which has an impact on the battery lifetime. Further, this allows faster charging.

- **Relevant product range**

Microprocessor controlled charging, as a general approach, is relevant both for standard (AA/AAA) and power tool battery chargers, as well as for other similar products.

- **Effects on Bill of Materials**

The BOM of a microprocessor controlled battery charger requires additional components for the control circuitry.

- **Environmental impacts**

Charging control requires an additional supply of power for the control circuitry. Consequently, the no-load and efficiency losses (in W) may increase. On the other hand, the charging control allows much shorter charging times, which in total leads to lower power consumption and power losses per charging cycle. (Table 7-4)

Table 7-4 – Comparison of conventional slow chargers and microprocessor controlled chargers

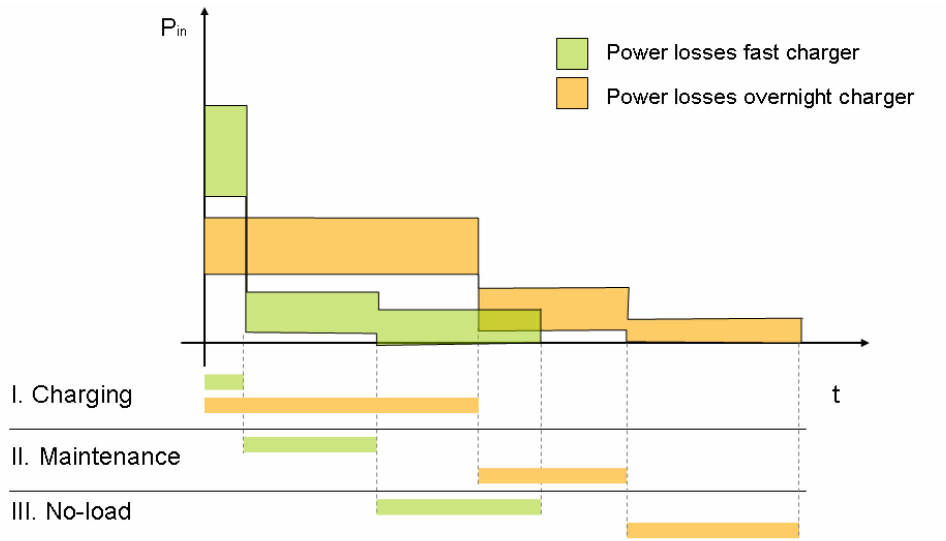
	Conventional overnight/slow charger	**Microprocessor controlled charger**
Charging time	> 6 hours	approx. 1 hour
Charging control	none, timer, temperature	microprocessor controlled
Total energy consumption in charging mode (tendency)	↗ (lower load, but for a much longer time)	↘ (short loading time)
Efficiency losses in maintenance and no-load mode (tendency)	↗ (related to linear technology)	↑ (overhead for charging control) ↘ (related to switch-mode technology)

The simplified[35] chart shown in Figure 7-3 outlines the power losses for the different operating modes. Such comparison becomes complicated by the fact that fast, microprocessor controlled chargers usually come with a switch-mode power conversion (as the load is higher) whereas overnight/slow chargers come

35 Not to scale. Power changes throughout the charging mode as well as throughout the maintenance mode (trickle charge); duration of maintenance mode and no-load mode assumed to be the same for both

usually with linear power supplies, at least for standard AA/AAA battery chargers (as the load frequently is in the range below 1 W).

Figure 7-3 – Schematic comparison of power losses for fast chargers (microprocessor controlled) and overnight chargers



Regarding power tool chargers, based on the BAT data presented in section 6.1.5 (task 6), following power losses per charging cycle can be assumed for an improved microprocessor controlled charger of about 50 W output:

- On-mode: 10 W (approximately 10% losses)
- Stand-by: 3 W
- No-load: 2.5 W

The energy consumption of BC is poorly documented and testing in common standard conditions would be needed to derive at meaningful conclusions, as the efficiency very much depend on the battery characteristics. Broader analysis, including real world testing[36] would be necessary to explore this issue in detail.

Besides the energy consumption issue, the effects on lifetime of batteries is an important issue. For standard AA/AAA battery chargers with microprocessor controlled charging, battery lifetime is assumed to be roughly twice that of overnight chargers. According to the assumed use patterns this would save 2 batteries over the 5 years lifetime of a battery charger. The energy saving potential per charger (i.e. per two batteries) can be roughly 28 MJ primary energy in the production phase as shown in Table 7-5.

36 Not in the scope of this study.

Table 7-5 – Savings potential for batteries by using microprocessor controlled chargers instead of a non-controlled charger (per charger)

Nr	Life cycle Impact per product:							Date	Author		
0	2 Batteries over 5 years lifetime of a battery charger							0	KSchi		

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			0			0	0	0	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			0			0	0	0	0
4	Non-ferro	g			0			0	0	0	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			55			42	14	55	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			55			42	14	55	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	21	7	28	0	0	1	2	-1	27
9	of which, electricity (in primary MJ)	MJ	0	0	0	0	0	0	2	-2	-1
10	Water (process)	ltr	2	1	3	0	0	0	1	-1	1
11	Water (cooling)	ltr	3	2	5	0	0	0	0	0	5
12	Waste, non-haz./ landfill	g	33	6	39	0	0	0	5	-5	35
13	Waste, hazardous/ incinerated	g	1	0	1	0	0	14	2	12	13
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1	0	2	0	0	0	0	0	2
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	8	3	11	0	0	0	1	-1	10
17	Volatile Organic Compounds (VOC)	g	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	mg Ni eq.	0	0	0	0	0	0	0	0	1
	PAHs	mg Ni eq.	11	0	11	0	0	0	0	0	11
20	Particulate Matter (PM, dust)	g	2	1	3	0	0	1	0	1	4
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	4	0	4	0	0	0	1	-1	3
22	Eutrophication	g PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

For the total market of 14 million overnight and timer-controlled standard AA/AAA battery chargers sold annually this improvement potential can result in saving a total of 0.38 PJ primary energy in the production phase[37].

[37] Due to rounding off in the EcoReport this does not appear in the table

Table 7-6 – Savings potential for batteries by using microprocessor controlled chargers instead of a non-controlled charger (new models sold over their lifetime)

Nr	EU Impact of New Models sold 2005 over their lifetime:							Date	Author		
0	2 Batteries over 5 years lifetime of a battery charger							0	KSchi		
	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	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			1			1	0	1	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			1			1	0	1	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	0	0	0	0	0	0
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	0	0	0	0	0
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	0	0	0	0	0
12	Waste, non-haz./ landfill	kt	1	0	1	0	0	0	0	0	1
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	0	0	0	0	0
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

Cost effects

For standard AA/AAA battery chargers, a significant price difference is observed on the market between slow overnight chargers and microprocessor controlled chargers.

For power tool chargers, a cost increase of 15-30 % has been indicated by a manufacturer (lower for professional products; higher for consumer do-it-yourself products).

Constraints / limitations

The main constraint for this approach is the cost difference of advanced chargers compared to overnight chargers without sophisticated control circuitry.

A huge number of OEMs offer such microprocessor controlled chargers already and it is a mature technology.

7.1.12 LIFETIME EXTENSION, MULTIPLE USE AND REUSE

Most manufacturers, when being asked for the reasons for lifetime limitation of EPS, stated incompatibility with next generation products. Consequently, the majority of external power supplies are assumed to be discarded along with the end-appliance. The technical lifetime usually exceeds the use lifetime. A principle improvement option is a standardisation of interfaces, namely connectors, to allow a reuse of the EPS with the next product generation or jointly for similar products. Further, EPS inclusion with a new product becomes optional if the compatibility issues are resolved.

In principle, this approach is also in-line with what the market requires, namely seeing portability as a valued commodity, “and likely to become more so, with many consumers now needing to carry a range of power supplies for their portable devices”[38].

However, such a concept only works without major changes / variations in the specification of the end-appliance, such as input voltage.

Currently there is a new work item proposal for ISO, titled “Harmonization for Interfaces for Battery Chargers and Consumer Goods powered by Rechargeable Batteries”[39], submitted by COPOLCO[40].

- **Relevant product range**

Although the proposal refers to “battery chargers” also external power supplies in the sense of this study (those powering the internal rechargeable batteries of an end-device) are included as well. Besides standardisation of interface of “charger” and device the proposal aims also at a standardisation of batteries.

The standard proposal follows a 3-step-approach[41]:

1. The vertical approach

Three major parameters have to be considered: voltage, chemical system, and capacity. In cases where these technical parameters are unified connector geometry (interface) of batteries and chargers, device and charger respectively,

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38 M. Ellis & Associates: Analysis of Potential for Minimum Energy Performance Standards – External Power Supplies, prepared for The Australian Greenhouse Office and NAEEEC under the National Appliance & Equipment Energy Efficiency Programme, Draft Final Report, October 2004

39 COPOLCO 42/2006: An International Standard for Harmonization for Interfaces for Battery Chargers and Consumer Goods powered by Rechargeable Batteries, October 2006

40 See also: Consumer Council of DIN German Institute for Standardization– New Work Item proposed by Standardization of rechargeable batteries / battery chargers, interface, 2006; G. Fleischer: Normung von Akkus, Ladegeräten und Schnittstellen – ein Vorteil für die Umwelt, 9. Treffen des Arbeitskreises “Richtlinienkonformes Design für WEEE / RoHS / EuP”, Frankfurt, 24 October 2006; G. Cornelissen, J. Forkert (Verbraucherrat des DIN Deutsches Institut für Normung e.V.): Machbarkeitsstudie zur Normung von Akkus und Anschlüssen an akkubetriebenen Geräten für Ladegeräte, October 2005

41 Cited from: Consumer Council of DIN German Institute for Standardization– New Work Item proposed by Standardization of rechargeable batteries / battery chargers, interface, 2006; referring to this standardisation is for documentation of possible approaches only and should not be seen as a direct outcome of the product group analyses in this study

shall be defined regardless of the commercial origin (supplier) of the product as a minimal first step to harmonisation.

2. Additional horizontal measures

2.1 Preference voltage

To gain further harmonisation groups of preferred voltage can be established. In relation with the suggested areas of application the table below gives recommendations.

Table 7-7 – Standardisation proposal: common voltages within areas of application

Voltage (V):	**1.2**	**2.4**	**3.6**	**4.8**	**6.0**	**7.2**	**8.4**	**9.6**	**10.8**	**12.0**	**14.4**	**15.6**	**18.0**	**24.0**
tools (diy)		X	X			X		X		X	X	X	X	X
mobile phone		**X**	**X**	**X**	X	X								
cordless phone	X	**X**	**X**	**X**										
notebook					X		X	X	X		X			
camera	X		X		**X**	**X**								
camcorder			X	X	**X**	**X**		X						

bold: match in voltage and case/construction/design
grey background: preferred voltage for selected groups of appliances

2.2 Chemical systems of batteries

The currently dominating four chemical systems: NiCd, NiMh, Li-Ion and Alkali-Manganese (RAM) can be reduced to two. The Nickel based systems are so similar that they can be treated as one based on NiMh charging technology. Due to the different cell voltage and a number of other special electrotechnical sensibilities Lithium-Ion and Lithium-Polymer batteries have to be treated as a second group. The Alkaline-Manganese systems cover only a very small portion of the market and may be therefore neglected.

2.3 Capacity

The third important parameter is the capacity of a battery or battery pack. The difference in capacity (mAh) has to be respected. In order to achieve additional harmonisation effects the method of establishing preferred groups can again be applied. The capacity groups, as suggested below, are based on application groups as defined for the preference voltage.

Table 7-8 – Standardisation proposal: preference groups according to the area of application

	Voltage (V)	Type	Capacity (mAh)
	(preference value)		*(preference value)*
tools (DIY)	**14.4/15.6/ 18.0**	**NiCd / NiMh**	**2000 – 3000**
mobile phone	**3.6 / 4.8**	**NiMh**	**700 – 900**
ditto	**3.6**	**Lithium**	**700 – 900**
cordless phone	**3.6 / 4.8**	**NiMh**	**600 – 1000**
notebook	**10.8 / 14.4**	**Lithium**	**3600 – 4000**
camera	**6.0 / 7.2**	**NiMh**	**700 - 1300**
ditto	**7.2**	**Lithium**	**700 – 1300**
camcorder	**6.0 / 7.2**	**NiMh**	**600 - 2000**
ditto	**7.2**	**Lithium**	**600 - 2000**

3. Best option

The table above combines all three parameters to preference groups by :

- Harmonising voltage and capacity as far as possible
- Treating NiMh and NiCd equally
- Keeping the Lithium systems separate
- Ignoring Alkali Manganese.

Battery chargers should be classified and marked in accordance with appropriate preferred group. Devices powered by rechargeable battery shall refer to the appropriate charger in the manual or on the packaging. Battery chargers have become low cost mass products. There is small expense for chargers providing adjustable voltage which again facilitates compatibility.

There are already universal power supplies on the market with switches to change output voltage and with a set of universal connectors to allow operation of various devices with different plug geometries.

Effects on Bill of Materials

There are no effects on the BOM per product, but fewer EPSs need to be manufactured in total. This means for every reused EPS is the BOM of one product saved.

Environmental impacts

The main environmental impact of standardisation of interconnections is the potential longer lifetime and the need for fewer external power supplies in general[42]. This results in reduced environmental impacts for production of external power supplies and reduction in the amount of waste.

However, longer lifetime of external power supplies might have an adverse environmental impact in case the next generation of EPSs is having much lower energy consumption (for example driven by general market trends or an EuP implementing measure). For the mobile phone base-case (per product, see the table in task 5) such a calculation looks as follows:

Primary energy consumption:

- Production: 26 MJ
- Use: 60 MJ[43]

It means that power consumption of the next generation of mobile phone EPS (after 3 years) have to be reduced by minimum 57% to offset the potential savings of not producing a new one. This is far beyond what seems to be realistic. The conclusion is: **Lifetime extension is an environmental benefit**.

On the other hand backwards compatibility of power supplies would allow also to use new, higher efficiency EPS / chargers also for products already in use.

Cost effects

In theory, the consumer can save the costs for each avoided external power supply. In practice this might be offset by the additional logistics costs (see constraints / limitations below). It is not always possible to reliably predict what the cost effects of such a change in business models would be, but at least there should not be an adverse effect on retail prices, as it is assumed as “worst case” that industry just follows “business as usual” without offering the alternative “product without EPS”. Unchanged business model leads to same retail price. In this context, one product to be explored is I-pod where EPS is not supplied anymore with the product and is an optional accessory.

Therefore the cost effect for the consumer will span the range: **Full retail price saved vs. same retail price.**

Constraints / limitations

The standardisation approach is likely to have no effect as long as the business model is to sell always an external power supply with the end-device and not to offer the choice to the consumer to buy a device without EPS. However, as the external power supplies are assumed to contribute between 3.50 Euro and 30 Euro to the sales prices, it might be a business strategy to offer “stand-alone” end-devices to lower the overall product price. The opposite effect of offering

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42 For example, as there are usually several mobile phones per household, all family members in principle could share one external power supply

43 This calculation does not take into account the calculated 52 MJ for the distribution for the reasons mentioned in task 5 and end-of-life, as disposal and recycling benefits for this base case nullify each other

products in two versions (with and without EPS) means additional (and costly) logistics.

The standardisation of EPS / chargers needs in parallel a standardised information about technical parameters (e.g. voltage, capacity, chemical system of the battery) to enable consumers to find the suitable device.

The end-device manufacturer usually specifies the requirements for the external power supply, also taking into account the safety, reliability and liability aspects and therefore may not favour the possibility that the consumer operates the device with an EPS not specified for this application. For example, cordless phones and answering machines require a specific surge protection as the appliance operates connected to the grid as well as to the telecommunication network. Keeping both circuitries strictly separated is an essential safety feature, which is taken into account when specifying cordless phone EPSs[44]. Other appliances, such as printers, typically have specific peak power requirements.

For power tools specifically, the concern is that standardisation involves the offering of cordless tools without chargers or even without batteries and shifting the responsibility for putting a workable set of a tool, battery and charger together to the user. This leads to critical risks because of following reasons[45]:

- typical for power tool applications, very short recharging times are requested (down to 10 minutes) leading to very high charge currents with potentially harmful situations when charge termination doesn't work properly due to any mismatch between system components.
- power tool battery concepts are continuously developing in the direction of lower impedance and higher discharge rates for peak power. Consequently uncontrolled discharge situations are dangerous and cannot be completely avoided by means like fuses because peak power in regular tool applications is close to a short circuit.
- capacity and energy content are growing continuously to allow substitution of more and more corded tools by more convenient cordless tools. Consequently the changing behaviour of the battery cells needs to be reflected in the charging system. Use of a previous charger would hinder further progress in battery evolution.
- product liability can only be limited to original setups of tool, battery and charger. Although more and more effort is put in to identify original equipment through housing design and labels, even today accidents occur due to incorrectly replaced batteries or chargers. This is likely to increase if tools were sold without chargers.

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44 See for example J. Haynes at Committee Workshop before the California Energy Resources Conservation and Development Commission in the matter of: Appliance Standards for External Power Supplies and Other Consumer Electronic Products, Sacramento (CA), January 30, 2006

45 The statements below are based on a stakeholder comment given by G. Flinspach, Bosch, January 4, 2007, taking into account a teleconference discussion between the consultants, Recharge and industry on December 21, 2006

The standardisation of batteries of the end devices is partly in contradiction to the market trends towards higher battery capacities (to serve the power intensive system needs and to allow longer battery powered operation times / mobile use), which as a secondary effect, asks for higher output power of the EPS to reduce charging times for user convenience.

These constraints and limitations lead to the conclusion that potential standardisation activities on this aspect need thorough investigation and discussion with the stakeholders. These aspects are beyond the scope of this study and should be part of the standardisation project.

7.1.13 CONSUMER BEHAVIOUR: REDUCTION OF NO-LOAD TIMES

No-load times of external power supplies and battery chargers are a question of consumer behaviour. For convenience, external power supplies frequently are left plugged in even when no end-device is connected. These no-load times in principle can be reduced without adverse effects on functionality.

In principle, consumer behaviour is a question of consumer awareness, which can be achieved with any kind of information and/or technical measures, such as indicator lights, which actually are part of some EPS and most battery chargers.

Relevant product range

No-load times are relevant for most of the external power supplies and battery chargers, but with some exemptions due to the typical use profile:

- External transformers for halogen lighting are usually switched on/off on the primary side. Consequently the transformers in no-load are disconnected from the mains. This might be different for halogen lightings, such as floor standing lamps, which have a mains cable to be plugged in to a socket and a switch on the secondary side.
- Power supplies for some devices are “always-on”, e.g. for cordless phones, and no-load is not of relevance to these devices[46].

Effects on Bill of Materials

Basically, changing the consumer behaviour has no influence on the BOM. However, some measures are thinkable to influence user behaviour, which would change the BOM, such as a switch on the primary side or a warning signal (acoustic, light, etc.) when the end device is disconnected.

46 On the other hand, there are some fields of application for external power supplies, where the EPS is assumed to be connected always to the end-device, such as stationary office equipment, such as printers, modems, which per definition are never in no-load (= disconnected), but are subject to user behaviour influence as well as they in principle could be disconnected from the grid as well, once the end-device is switched off.

Environmental impacts

The environmental impacts of no-load losses for the different base-cases in total are listed in Table 7-9 below. The no-load losses for the stock add up to 1.88 TWh electricity consumption. In principle, this is the improvement potential, i.e., the maximum achievable environmental benefits if all the no-load losses are avoided.

As can be seen from the table, a number of base-cases do not contribute to the no-load losses, either because they are assumed to be constantly under load (EPS fro DECT phone, set-top box / modem and printer), they are assumed to be unplugged immediately after the use (personal care appliances) or they have an off-switch at the primary side (halogen lighting transformers). Regarding other base-cases, the no-load consumption largely depends on the assumptions regarding user behaviour[47].

As some end-applications, such as medical equipment and monitors are not explicitly covered by the base case calculations, the no-load losses actually exceed 2 TWh. For this calculation the uncertainties regarding the user behaviour and especially regarding no-load times have to be kept in mind.

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47 In this study, the aim was to use realistic, not necessarily worst-case, estimates (see also Cost effect below.

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Table 7-9 – Total no-load losses of EPS and BC[48]

Lot 7 Active vs No-load losses for the base-cases (per EU25 2005 stock)

Base-cases		Unit	EPS for: Mobile phone	EPS for: DECT phone	EPS for: Digital camera	EPS for: Set-top box / modem	EPS for: Personal care appliance	EPS for: Printer	EPS for: Laptop (–PFC)	EPS for: Laptop (+PFC)	Transformer for halogen lighting (Magnetic)	Transformer for halogen lighting (Electronic)	Standard battery charger	Power tool charger	Lot 7 TOTAL
Total consumption per year (per unit)	(a)	kWh	1,89	10,27	1,36	17,84	7,72	12,93	43,92	58,44	43,80	14,21	4,81	1,47	
No-load: consumption per hour	(b)	kWh	0,0003	0	0,0003	0	0	0	0,00125	0,00125	0	0	0,0023	0,004	
No-load: number of hours	(c)	hrs/year	3650	0	3650	0	0	0	4927,5	4927,5	0	0	1003,75	86,14	
No-load: share of electricity cons.	**(d)**	%	**58%**	**0%**	**80%**	**0%**	**0%**	**0%**	**14%**	**11%**	**0%**	**0%**	**48%**	**24%**	**11%**
Stock (2005)	(e)	units	807.100.000	150.000.000	108.300.000	68.700.000	40.000.000	120.800.000	80.000.000	20.000.000	100.000.000	100.000.000	100.000.000	77.000.000	
Total electricity consumption (in use) of the stock per year	(f)	TWh	1,53	1,54	0,15	1,23	0,31	1,56	3,51	1,17	4,38	1,42	0,48	0,11	17,39
No-load consumption of the stock per year	**(g)**	TWh	0,88	0,00	0,12	0,00	0,00	0,00	0,49	0,12	0,00	0,00	0,23	0,03	**1,88**

(a) see EIA of base-cases
(b) see task 4
(c) see task 4
(d) b × c / a
(e) see task 2
(f) a × e /10^9
(g) d × f

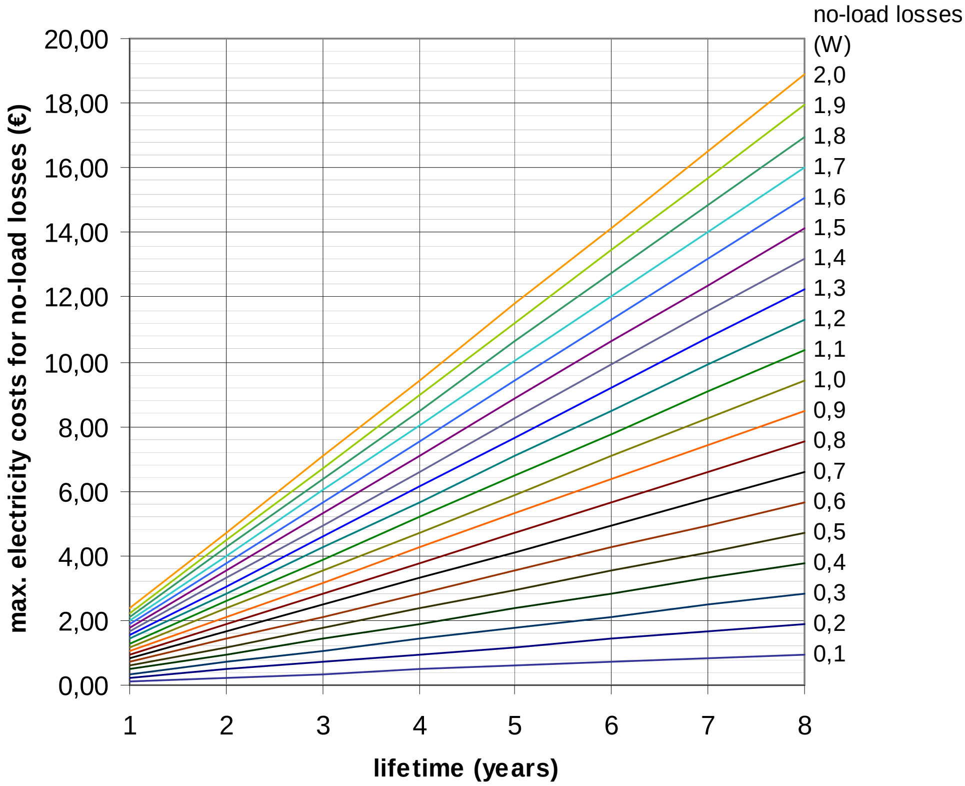
48 Energy data refers to electricity, Do not compare these values with PRIMARY energy data listed in most other assessments without adaptation. For comparison: 2 TWh_{el} equals 21 PJ_{GER}

Cost effects

1.88 TWh electricity consumption annually corresponds to **electricity costs of 255.68 million €**. However, it is assumed that no matter what measures might be undertaken to influence consumer behaviour the full savings potential can by far not be realised.

With a worst-case scenario maximum no-load electricity costs can be calculated per product to give an indication for the maximum savings potential. Such a scheme is provided below in Figure 7-4.

Figure 7-4 – Worst-case no-load electricity costs over the product lifetime[49]



Besides these saving potentials, appropriate measures are needed to stimulate the consumer in order to avoid no-load times.

Constraints / limitations

The only limitation to the reduction of consumer behaviour related no-load losses is the willingness of the consumer himself to unplug the external power supply or battery charger. This effect cannot be estimated or quantified reliably.

49 The graph has to be read as follows: For a power supply with 5 years assumed lifetime (x-axis) and no-load losses of e.g. 1.2 W (legend for no-load losses isobars on the right hand side) the maximum electricity costs for these no-load losses (24 hours daily, 365 days per year in no-load @ 0.136 €/kWh) in total are approx. 7 € over the lifetime.

7.1.14 ADDITIONAL TECHNICAL OPTIONS

There are additional technical options which are not described here in detail but which may allow improvement of external power supplies, halogen lighting transformers, and battery chargers. For example, **low loss materials for transformer cores** (steel and ferrites) which allow a more efficient power transformation, but price differences are significant.

As the detailed environmental assessments concluded that the **copper in cables** are of certain relevancy, this aspect needs to be addressed. Usually, the length of the cable for EPS is specified by the customer, a standard length in the EU being 2 meters[50]. Reducing the diameter of the copper has a negative effect on resistance, but there is already the market trend towards less copper diameter to allow more flexible cables. The only recommended eco-design measure simply is to shorten the cables, but of course, that might have an impact on user convenience. On the other hand, the cable and mains plug makes up roughly 1 € of the whole retail price of the external power supply. A reduction of cable length therefore has a positive effect on LCC. Regarding battery chargers these considerations suggest that plug-in devices are preferable to tabletop chargers.

7.1.15 COMBINATION OF TECHNICAL OPTIONS

In the previous sub-sections, technology and component modifications have been looked at as improvement options. However, designing an electronic layout is a very complex, multi-parameter task, which usually needs thorough balancing of several dozen individual components. Hence, it is not possible to give a dedicated improvement option per technology/component (as it is usually impossible to implement only one option or component without adjusting all other components). Furthermore, following several improvement strategies in parallel does not mean, that the achievable effects can always be cumulated.

An alternative approach to quantify achievable improvements (improvement potential) is to look at the progressive products on the market. Their existence on the market proves that they employ available technologies and their performance parameters show what (at least) is achievable. In the following sub-section, the achievable efficiencies and no-load losses, based on EnergyStar phase 1 specifications are discussed first. The top “best in class” efficiency and no-load performance will be assessed at the end of this sub-section.

50 Compared to 1.5 m in Japan

Baseline: Energy Star, Phase 1[51]

Baseline regarding achievable efficiencies and no-load losses are the requirements of the Energy Star specification (phase 1) demonstrated by the fact that there are currently 437 external power supplies listed as being ES compliant, which are specified for 230 V AC input and which span the whole spectrum of power output range[52].

In conjunction with the Californian mandatory requirements (same as Energy Star, phase 1) for external power supplies the point has been raised, that it might be difficult for **low voltage** power supplies to meet the standards due to physical limitations, which result in lower efficiencies[53].

Figure 7-5 shows an evaluation of the current Energy Star database, one spot for each EPS that is compliant with the current Energy Star requirements, with the nameplate output voltage on the x-axis and output wattage on the y-axis.

In the low wattage range (1-10 W) there are only 3 Energy Star compliant EPS with a significantly lower output voltage than 5 V (down to 3 V for the Energy Star compliant EPS with the lowest wattage of all – at 1.2 W), and two more with only a slightly lower voltage at 4.8 V:

- Obviously, there is a **lower barrier for Energy Star compliance at 5 V output voltage** for power supplies with **up to 11 W rated output power**.
- **Above 11 W rated output power**, there is a huge amount of compliant EPS with an **output voltage of 12 V**.
- **Above 60 W**, there is only one compliant EPS with 12 V (100 W), all others start with **15 V**.
- **Above 120 W** all compliant EPS have rated output voltage of **18 V** and above. However, there is only a limited number of EPS in this wattage range.

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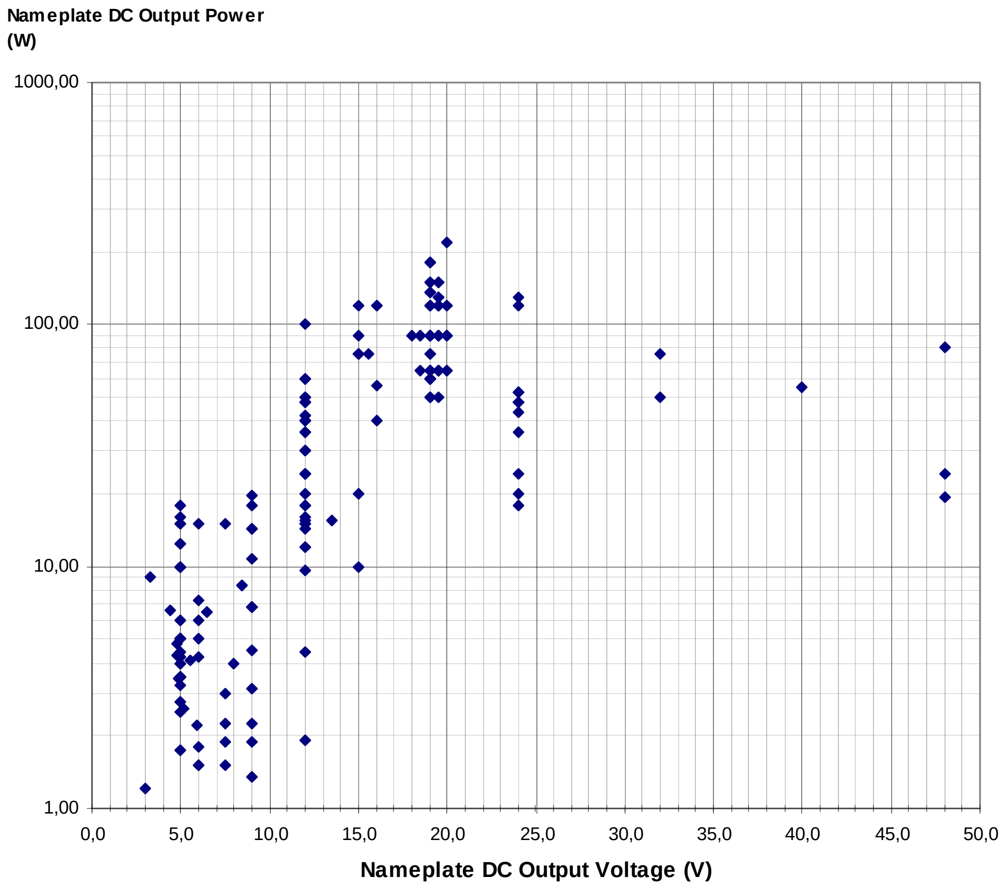
51 Halogen lighting transformers are not discussed here, but only in the “best in class” section.

52 it has not been checked (nor is such a check feasible based on the data in the Energy Star list), if all specifications for all kinds of end-appliances are represented

53 Committee Workshop before the California Energy Resources Conservation and Development Commission in the matter of: Appliance Standards for External Power Supplies and Other Consumer Electronic Products, Sacramento (CA), January 30, 2006

Figure 7-5 – Output power in correlation with output voltage of Energy Star compliant external power supplies



Consequently, besides the above mentioned voltage constraints, an average efficiency as follows can be assumed to be state-of-the-art:

Rated Output Power (P_{no}) (in watts)	Average Efficiency in Active Mode
$0 < P_{no} \leq 1$	$0.49 \times P_{no}$
$1 < P_{no} \leq 49$	$[0.09 \times \mathrm{Ln}(P_{no})] + 0.49$
$49 < P_{no} \leq 250$	0.84

No-load power consumption of **0.5 W** and **0.75 W** for external power supplies with rated output power below 10 and from 10 W upwards respectively can be assumed to be state-of-the-art as well.

Compared to the assumptions for the base cases it is evident that for the external power supplies only the base cases on laptops (with and w/o PFC) do not meet the Energy Star criteria[54].

It can be assumed that laptop EPS can meet the Energy Star, phase 1 criteria easily without significant changes in retail prices (as such EPS are already on the market at competitive prices, just the current average seems still to be lower).

Table 7-10 – Baseline Energy Star, phase 1, as state-of-the-art

Base Case	Average Efficiency	Average no load power losses (in watts)
laptop EPS, 65W (w/o PFC)	84%	0.75 W
laptop EPS, 90W (w PFC)	84%	0.75 W

- **Implementation of technical options listed in sections 7.1.2, 7.1.4 to 7.1.10**

Taking into account the full range of the technical improvement options discussed in the previous sub-sections, either being implemented as alternatives or jointly, the efficiency and no-load levels listed in Table 7-11 can be assumed to be achievable with today's technology – and actually such products are currently already in the market.

54 50% of the power supplies tested in the joint Australian-Chinese-US test campaign in the power ranges 2.5 – 6 W already achieved the no load power loss level of 0.5 W, and 38.2% for all output power classes met the 0.5/0.75 conditions; 32.7 % of tested power supplies over all power classes already met the efficiency conditions – having in mind the assumed larger share of linear designs at that time (M. Ellis & Associates: Analysis of Potential for Minimum Energy Performance Standards – External Power Supplies, prepared for The Australian Greenhouse Office and NAEEEC under the National Appliance & Equipment Energy Efficiency Programme, Draft Final Report, October 2004)

Table 7-11 – Efficiency and no load losses using combination of various improvement options

Base Case	Average Efficiency	Average no load power losses (in watts)
mobile phone EPS	65%	0.3 W
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
DECT phone EPS	65%	not relevant
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
personal care appliance	65%	0.3 W
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
digital camera EPS	71%	0.3 W
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
set-top box / modem EPS	71%	0.3 W
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
printer EPS	78%	0.5 W
	primary integrated IC, synchronous rectification and/or resonant switching etc.	
laptop, 65W (w/o PFC)	85%	0.5 W
	synchronous rectification and/or resonant switching etc.	
laptop, 90W (w PFC)	85%	0.5 W
	single-stage flyback topology, active PFC stage, PFC switch-off at low load	

As these efficiencies and no-loads are all already available on the market – usually in very price sensitive segments, such as the mobile phone market – this is an indication that these designs can be used without prohibitive additional manufacturing costs. According to industry estimates the cost increase – if at all – will be in the order of magnitude of 5% maximum[55].

55 For the comparison: The identified improvement options are largely in the range of the Californian mandatory standards taking effect in 2008: Results from the Advisory Committee for NYSERDA Appliances Standards for EPS show, that the change-over to high-efficiency power supplies (basis are the mandatory standards for Power Supplies in California effective July 1, 2008) lead to reduced life cycle costs for all output power ranges (assumptions are a 5 years lifetime – which is not in compliance with all the assumed lifetimes within this EuP preparatory study -, and electricity costs of US$ 0.133/kWh – compared to € 0.136/kWh). The stated lifetime savings per unit vary between US$ 0.76 for power supplies in the range below 1 W (which is a very minor market

Best in class

The best external power supplies on the market currently give an indication, what is possible with today's technology in principle. In the Energy Star list the following average efficiencies and no-load losses are achieved by best in class products per output class[56]. In most cases it is not known, which technical options have been implemented and if patented technologies have been applied. It is not feasible to check all the given specifications and to test them in the scope of this study.

Table 7-12 – Best in class power supplies from the Energy Star product list[57]

Rated Output Power (P_{no}) (in watts)	Average Efficiency	Average no load power losses (in watts)	Power range corresponds to following base case(s)
$0 < P_{no} \leq 1.5$	55%	0.02 W	-
$1.5 < P_{no} \leq 2.5$	65%	0.16 W	DECT phone
$2.5 < P_{no} \leq 4.5$	71%	0.21 W	mobile phone
$4.5 < P_{no} \leq 6$	73%	0.20 W	personal care product
$6 < P_{no} \leq 10$	79%	0.15 W	digital camera, set-top box / modem
$10 < P_{no} \leq 25$	85%	0.13 W	printer
$25 < P_{no} \leq 65$	88%	0.25 W	laptop, 65W
$65 < P_{no}$	89%	0.43 W	laptop, 90W

Regarding halogen lighting transformers, there are units on the market, which achieve 96% efficiency (compared to 92.5% assumed for the electronic transformer base case)[58], but at a significantly higher price than other electronic transformers[59].

segment, for power supplies. As the calculating approach undertaken by Ecos Consulting for this analysis is different from the approach prescribed by the MEEuP methodology report this can serve only as a fact and does not replace the life cycle costing for this study.

56 Actually, the third-best product (based on average efficiency) is listed here to rule out typing errors, major measurement errors etc. which might have made it into the Energy Star list

57 Qualified Product (QP) List for ENERGY STAR® Ac-Dc Qualified External Power Supplies, List Current as of October 29, 2006

58 e.g. from Osram

59 Approx. twice the price

7.2. ANALYSIS LLCC AND BAT

The LLCC and BAT analysis is the most important step in the MEEUP where the suggested improvement options are evaluated for their environmental and economic implications extending over the complete life cycle of the product.

The objective of this sub-task is to analyse design options (which in turn are based on improvement potentials) using EcoReport and then prioritise them according to their life cycle costs (LCC) in order to identify the option using the BAT and with least life cycle cost (LLCC). Different improvement options can be accumulated together if applicable to a specific base-case or product. Following subsections presents such options (or a combination of options) and their respective LCC.

The analysis of principle improvement options in 7.1 leads to a list of options (Table 7-13), which are partly combined options. This list is already sorted according to decreasing life cycle costs and likely environmental impacts. However, for different fields of application this prioritisation is likely not to be coherent throughout all analysed key applications.

Table 7-13 – Applicability of improvement options per base-case

key application	external power supply									charger	
	mobile phone	DECT phone	digital camera	set-top box / modem	personal care appliance	printer	laptop (w/o PFC)	laptop (with PFC)	halogen lighting transformer	standard battery charger	power tools
(1) Base-line: Energy Star EPS, phase 1							x	x			
(2a) Implementation of various technical options (incl. change from linear to switch-mode)	x	x	x	x	x	x	x	x		x	x
(2b) Change from magnetic to electronic transformers									x		
(3) Production related effects of differentiation within the SMPS market (reduction of 10% in BOM)	x	x	x	x	x	x	x	x	x	x	x
(4) Consumer behaviour towards no-load	x		x		x		x	x		x	x
(5) Microprocessor controlled charging										x	x
(6) Lifetime extension: standardisation of interfaces / connectors	x	x	x	x	x	x	x	x			x
(7) “Best in class”	x	x	x	x	x	x	x	x			

To compare the improvement results of the individual options, see the base case results in task 5 and summarised in the table below to clarify the starting point of the following LLCC / BAT discussion.

Table 7-14 – EIA and LCC for the base-cases, per product

Lot 7 Total environmental impacts PER PRODUCT													
Base-cases / Main life cycle indicators	Unit	EPS for								Transformer for halogen lighting		Standard battery charger	Power tool charger
		Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (–PFC)	Laptop (+PFC)	(Magnetic)	(Electronic)		
Total Energy (GER)	MJ	138	808	120	766	398	656	2444	3237	5192	1624	395	367
of which, electricity	MJ	63,5	644,8	45,9	550,9	329,1	554,7	2326,9	3073,1	4589,4	1494,2	254,0	125,8
Water (process)	ltr.	167,2	1744,5	123,1	1530,4	871,2	1466,5	6167,7	8211,1	12441,2	3993,3	694,6	292,6
Waste, non-haz./ landfill	g	326,9	1239,3	671,7	1048,6	753,4	1116,5	3824,2	5013,0	6257,8	2179,8	1159,9	1192,8
Waste, hazardous/ incinerated	g	61,9	153,0	63,7	218,5	68,3	143,5	188,6	288,3	627,7	152,0	141,7	385,8
Emissions (Air)													
Greenhouse Gases in GWP100	kg CO_2eq.	8,7	39,1	7,8	38,0	20,0	31,7	110,1	145,2	236,8	74,3	21,1	21,4
Acidifying agents (AP)	g SO_2eq.	39,3	218,9	38,9	206,9	108,2	181,3	649,5	856,3	1384,9	427,8	119,3	134,4
Volatile Org. Compounds (VOC)	g	0,2	0,9	0,2	1,1	0,2	0,5	1,3	1,7	4,8	1,0	0,6	1,2
Persistent Org. Pollutants (POP)	ng i-Teq.	0,9	5,1	0,8	4,8	2,7	4,3	16,4	21,7	32,9	11,0	3,4	2,7
Heavy Metals (HM)	mg Ni eq.	6,3	18,9	6,6	17,8	11,5	17,7	51,6	65,8	97,3	32,7	26,2	22,6
PAHs	mg Ni eq.	8,3	42,4	7,0	61,2	5,9	14,7	23,1	40,2	210,0	32,3	28,5	56,1
Particulate Matter (PM, dust)	g	7,9	27,6	7,5	38,1	8,6	17,5	30,8	46,9	125,7	24,1	22,3	50,1
Emissions (Water)													
Heavy Metals (HM)	mg Hg/20	2,8	14,4	4,0	17,5	4,5	7,7	23,3	33,3	89,4	16,6	18,0	16,6
Eutrophication (EP)	g PO_4	0,1	0,3	0,1	0,2	0,1	0,3	0,3	0,4	2,9	0,2	0,4	0,7
Lot 7 LCC new product													
Product price	€	3,50	3,50	6,50	6,50	3,50	12,50	30,00	30,00	20,00	20,00	15,00	19,50
Electricity	€	0,70	7,09	0,50	6,61	3,72	6,24	25,86	34,41	46,00	14,92	2,83	0,94
TOTAL consumer expenditure	€	4,20	10,59	7,00	13,11	7,22	18,74	55,86	64,41	66,00	34,92	17,83	20,44

7.2.1 OPTION 1: BASE-LINE - ENERGY STAR EPS, PHASE 1

To achieve an Energy Star, phase 1 levels affects – having the base cases as starting point (see argumentation above) – only the laptop EPS base cases will be affected (see Table 7-10).

As the exact change in BOM is not known and the changes in retail price are estimated negligible, only the energy consumption figures have been adapted for the EcoReport calculations. The EIA and LCC per product, after the necessary modification to achieve the above-mentioned limits, are presented in Table 7-15.

Table 7-15 – EIA and LCC for the implementation of Option 1, per product (this option is only relevant for laptop EPS)

Lot 7 Total environmental impacts PER PRODUCT			
Base-cases / Main life cycle indicators	EPS for		
	Unit	Laptop (–PFC)	Laptop (+PFC)
Total Energy (GER)	MJ	2052	2744
of which, electricity	MJ	1935,3	2580,7
Water (process)*	ltr.	136	178
Waste, non-haz./ landfill*	g	3370	4442
Waste, hazardous/ incinerated*	g	180	277
Emissions (Air)			
Greenhouse Gases in GWP100	kg CO_2eq.	93,0	123,7
Acidifying agents (AP)	g SO_2eq.	548,7	729,5
Volatile Org. Compounds (VOC)	g	1,1	1,6
Persistent Org. Pollutants (POP)	ng i-Teq.	13,9	18,4
Heavy Metals (HM)	mg Ni eq.	44,9	57,3
PAHs	mg Ni eq.	22,4	39,2
Particulate Matter (PM, dust)	g	28,6	44,2
Emissions (Water)			
Heavy Metals (HM)	mg Hg/20	20,8	30,1
Eutrophication (EP)	g PO_4	0,3	0,4
*=caution: low accuracy for production phase			
Lot 7 LCC new product			
Product price	€	30,00	30,00
Electricity	€	21,47	28,89
TOTAL consumer expenditure	€	51,47	58,89

7.2.2 OPTION 2: IMPLEMENTATION OF TECHNICAL OPTIONS LISTED IN SECTIONS 7.1.2, 7.1.4 TO 7.1.10

A large share of the EPS market is already using switch mode energy conversion technology. For the fraction of linear products, the change-over is a realistic improvement option. Furthermore, various technical options can be adopted to improve the switch-mode supplies (Table 7-11).

In order to quantify the impacts of implementing this option, the energy consumption figures and BOMs have been adapted in the EcoReport calculations to reflect the composition of switch-mode power supplies[60]: The BOMs for DECT phones and mobile phones are set the same. For the set-top box / modem case the linear EPS BOM entries have been replaced by an SMPS design.

The change from magnetic to electronic transformers (corresponding to linear and switch-mode of other EPS, respectively) leads to a merging of the base

60 For base-cases whose market is a mixture of switch-mode and linear mode products, the base-case was constructed as a weighed average of the two, according to the market shares. For example, the mobile phone base-case is 20% linear and 80% switch-mode.

cases for magnetic and electronic transformers, based on 92.5 % efficiency and the material composition of electronic transformers.

The IEA and LCC for the base-cases (per product) corresponding to the implementation of this option is shown in Table 7-16.

Table 7-16 – EIA and LCC for the implementation of Option 2, per product

Lot 7 Total environmental impacts PER PRODUCT												
Base-cases / Main life cycle indicators	Unit	EPS for								Transformer for halogen lighting		Power tool charger
		Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (–PFC)	Laptop (+PFC)	(Magnetic)	(Electronic)	
Total Energy (GER)	MJ	131	497	120	648	371	572	1861	2505		1624	339
of which, electricity	MJ	66,0	430,8	45,5	547,2	302,2	471,1	1744,2	2340,9		1494,2	97,9
Water (process)*	ltr.	7	31	5	44	24	39	124	162		106	27
Waste, non-haz./ landfill	g	330	753	671	1108	722	1020	3149	4164		2180	1160
Waste, hazardous/ incinerated	g	53	62	64	143	68	142	175	271		152	385
Emissions (Air)												
Greenhouse Gases in GWP100	kg CO_2eq.	8,3	24,2	7,8	31,4	18,8	28,1	84,7	113,2		74,3	20,2
Acidifying agents (AP)	g SO_2eq.	37,3	131,4	38,8	179,4	101,3	159,8	499,4	667,7		427,8	127,2
Volatile Org. Compounds (VOC)	g	0,1	0,3	0,2	0,5	0,2	0,5	1,1	1,5		1,0	0,0
Persistent Org. Pollutants (POP)	ng i-Teq.	0,9	3,3	0,8	4,2	2,6	3,7	12,6	16,9		11,0	2,5
Heavy Metals (HM)	mg Ni eq.	6,1	12,4	6,6	17,6	11,0	16,3	41,6	53,2		32,7	22,2
PAHs	mg Ni eq.	4,5	5,2	7,0	14,7	5,8	14,5	22,0	38,7		32,3	56,0
Particulate Matter (PM, dust)	g	6,1	8,2	7,5	17,5	8,4	17,1	27,6	42,9		24,1	49,9
Emissions (Water)												
Heavy Metals (HM)	mg Hg/20	1,9	4,3	3,9	7,7	4,3	7,2	19,5	28,6		16,6	16,4
Eutrophication (EP)	g PO_4	0,1	0,1	0,1	0,3	0,1	0,3	0,3	0,4		0,2	0,7
*=caution: low accuracy for production phase												
Lot 7 LCC new product												
Product price	€	3,68	3,68	6,83	6,83	3,68	13,13	31,50	31,50		20,00	21,45
Electricity	€	0,71	4,66	0,50	6,30	3,41	5,28	19,32	26,20		14,92	0,63
TOTAL consumer expenditure	€	4,39	8,34	7,32	13,12	7,09	18,40	50,82	57,70		34,92	22,08

For halogen lighting transformers this option means that the “magnetic base case” improvement ends up to be the same as the unchanged “electronic base case”. The consumer, who used a magnetic one before, according to this option is using an electronic one thereafter – with the related LCC effects. For the base case scenario (primary side switch) this means a total energy reduction from 5129 MJ to 1624 MJ per unit, for the alternative scenario with secondary side switch the change is from 7645 MJ to 1747 MJ GER. The trend for the alternative scenario is the same but the absolute improvement potential is much higher.

According to evidence provided by manufacturers, the product price increase to achieve improvements in the power tool segment as outlined in 7.1.11 is below 2 Euros per unit, meaning a relative increase of 10%.

7.2.3 OPTION 3: REDUCTION IN THE BILL OF MATERIALS

Miniaturisation and reduction in the BOM can be an aim in itself, but in general they can only be achieved by the use of improved and more efficient (switch-mode) technology. So, the impacts of this option, which assumes 10% reduction in all the materials of the BOM, can only be realised in combination with the Option 2. Such a combination is assessed in the next sub-section.

7.2.4 OPTION 2+3: IMPLEMENTATION OF TECHNICAL OPTIONS LISTED IN SECTIONS 7.1.2, 7.1.4 TO 7.1.10 AND REDUCTION IN THE BILL OF MATERIALS

This option assumes the change-over of the whole market from linear to switch-mode technology, implementation of some additional technical options for improved switch-mode efficiency, and a 10% reduction in the BOM. The EIA and LCC per product of this combination for the base-cases are presented in Table 7-17.

Table 7-17 – EIA and LCC for the implementation of Option 2+3, per product

Lot 7 Total environmental impacts PER PRODUCT												
Base-cases / Main life cycle indicators	Unit	EPS for								Transformer for halogen lighting		Power tool charger
		Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (–PFC)	Laptop (+PFC)	(Magnetic)	(Electronic)	
Total Energy (GER)	MJ	129	495	117	642	369	566	1853	2493		1616	316
of which, electricity	MJ	65,5	430,3	45,2	546,0	301,7	470,0	1742,0	2340,4		1493,9	93,8
Water (process)	ltr.	7	31	5	43	23	38	123	162		105	25
Waste, non-haz./ landfill	g	309	732	614	1064	690	976	3039	4024		2140	1056
Waste, hazardous/ incinerated	g	48	57	58	130	62	129	162	250		140	347
Emissions (Air)												
Greenhouse Gases in GWP100	kg CO_2eq.	8,2	24,1	7,7	31,1	18,7	27,7	84,2	112,5		73,8	18,9
Acidifying agents (AP)	g SO_2eq.	36,3	130,4	37,3	176,4	100,0	156,9	495,1	662,3		424,7	117,2
Volatile Org. Compounds (VOC)	g	0,1	0,3	0,2	0,5	0,2	0,5	1,0	1,4		1,0	0,0
Persistent Org. Pollutants (POP)	ng i-Teq.	0,9	3,3	0,8	4,2	2,5	3,7	12,5	16,7		10,9	2,3
Heavy Metals (HM)	mg Ni eq.	5,9	12,2	6,3	17,0	10,7	15,7	40,7	52,2		32,3	20,3
PAHs	mg Ni eq.	4,3	5,1	6,6	13,6	5,5	13,4	20,4	35,6		29,6	50,7
Particulate Matter (PM, dust)	g	5,5	7,7	6,8	16,1	7,8	15,7	25,9	40,1		22,6	45,1
Emissions (Water)												
Heavy Metals (HM)	mg Hg/20	1,8	4,1	3,6	7,3	4,1	6,8	18,7	27,2		15,9	14,8
Eutrophication (EP)	g PO_4	0,1	0,1	0,1	0,2	0,1	0,2	0,3	0,4		0,2	0,6
Lot 7 LCC new product												
Product price	€	3,68	3,68	6,83	6,83	3,68	13,13	31,50	31,50		20,00	21,45
Electricity	€	0,71	4,66	0,50	6,30	3,41	5,28	19,32	26,20		14,92	0,63
TOTAL consumer expenditure	€	4,39	8,34	7,32	13,12	7,09	18,40	50,82	57,70		34,92	22,08

7.2.5 OPTION 4: CONSUMER BEHAVIOUR TOWARDS NO-LOAD

Option 4 comprises measures to influence user behaviour as to avoid the no-load losses. The EIA and LCC presented in Table 7-18 reflect the potential of such no-load reduction. I.e., this is a best-case assessment, the actual effect being somewhere between the business-as-usual and the full potential. In the calculations, only the reduced electricity costs are taken into account, not the costs of whatever measures to influence user behaviour.

Obviously, reduction of no-load losses as an option is only relevant for applications that exhibit such losses in the first place. Hence, in Table 7-18 only those end-applications are listed for which the base-case assessment considered no-load to be relevant.

Table 7-18 – EIA and LCC for the implementation of Option 4

Lot 7 Total environmental impacts PER PRODUCT							
Base-cases / Main life cycle indicators	Unit	EPS for Mobile phone	EPS for Digital camera	EPS for Laptop (–PFC)	EPS for Laptop (+PFC)	Standard battery charger	Power tool charger
Total Energy (GER)	MJ	104	85	2121	2913	274	347
of which, electricity	MJ	29,0	11,4	2003,5	2749,8	132,8	105,9
Water (process)	ltr.	75,2	31,1	5305,4	7348,8	371,4	239,5
Waste, non-haz./ landfill	g	286,9	631,7	3449,2	4638,1	1019,3	1169,7
Waste, hazardous/ incinerated	g	61,1	62,9	181,2	280,8	138,9	385,3
Emissions (Air)							
Greenhouse Gases in GWP100	kg CO_2eq.	7,2	6,3	96,0	131,0	15,8	20,5
Acidifying agents (AP)	g SO_2eq.	30,5	30,1	566,2	773,0	88,1	129,3
Volatile Org. Compounds (VOC)	g	0,2	0,2	1,2	1,6	0,5	1,2
Persistent Org. Pollutants (POP)	ng i-Teq.	0,7	0,6	14,3	19,5	2,6	2,6
Heavy Metals (HM)	mg Ni eq.	5,7	6,0	46,0	60,2	24,2	22,3
PAHs	mg Ni eq.	8,2	6,9	22,5	39,5	28,3	56,1
Particulate Matter (PM, dust)	g	7,7	7,3	29,0	45,1	21,6	50,0
Emissions (Water)							
Heavy Metals (HM)	mg Hg/20	2,6	3,7	21,2	31,2	17,2	16,4
Eutrophication (EP)	g PO_4	0,1	0,1	0,3	0,4	0,4	0,7
Lot 7 LCC new product							
Product price	€	3,50	6,50	30,00	30,00	15,00	19,50
Electricity	€	0,30	0,10	22,23	30,78	1,47	0,72
TOTAL consumer expenditure	€	3,80	6,60	52,23	60,78	16,47	20,22

7.2.6 OPTION 2+4: IMPLEMENTATION OF TECHNICAL OPTIONS LISTED IN SECTIONS 7.1.2, 7.1.4 TO 7.1.10 AND CONSUMER BEHAVIOUR TOWARDS NO-LOAD

Encouraging users to avoid no-load losses can be a complementary option to the realisation of the above-mentioned principle technical improvement options. However, the latter already partly tackle reduction of no-load losses. Hence, the impacts of such a combination are not cumulative.

Actually 1+4 is also a possible combined option, but not analysed here in detail, as it only concerns the laptop base-case.

Table 7-19 – EIA and LCC for the implementation of Option 2+4

Lot 7 Total environmental impacts PER PRODUCT					
Main life cycle indicators \ Base-cases	Unit	EPS for Mobile phone	EPS for Digital camera	EPS for Laptop (–PFC)	EPS for Laptop (+PFC)
Total Energy (GER)	MJ	97	85	1732	2375
of which, electricity	MJ	31,5	11,0	1614,8	2211,6
Water (process)*	ltr.	5	3	115	154
Waste, non-haz./ landfill	g	290	631	2999	4014
Waste, hazardous/ incinerated	g	53	63	172	268
Emissions (Air)					
Greenhouse Gases in GWP100	kg CO_2eq.	6,7	6,3	79,0	107,6
Acidifying agents (AP)	g SO_2eq.	28,4	29,9	466,1	634,4
Volatile Org. Compounds (VOC)	g	0,1	0,2	1,0	1,4
Persistent Org. Pollutants (POP)	ng i-Teq.	0,7	0,6	11,8	16,0
Heavy Metals (HM)	mg Ni eq.	5,6	6,0	39,4	51,0
PAHs	mg Ni eq.	4,4	6,9	21,7	38,5
Particulate Matter (PM, dust)	g	5,9	7,3	26,9	42,2
Emissions (Water)					
Heavy Metals (HM)	mg Hg/20	1,7	3,7	18,7	27,7
Eutrophication (EP)	g PO_4	0,1	0,1	0,3	0,4
*=caution: low accuracy for production phase					
Lot 7 LCC new product					
Product price	€	3,68	6,83	31,50	31,50
Electricity	€	0,31	0,09	17,87	24,75
TOTAL consumer expenditure	€	3,98	6,92	49,37	56,25

7.2.7 Option 2+3+4: Implementation of technical options listed in sections 7.1.2, 7.1.4 to 7.1.10 and reduction in BOM and consumer behaviour towards no-load

The combined option 2+4, which is presented in the previous sub-section, can be further combined with option 3, impacts being cumulative. The EIA and LCC of this combination are presented in Table 7-20.

Table 7-20 – EIA and LCC for the implementation of Option 2+3+4, per product

Lot 7 Total environmental impacts PER PRODUCT					
Main life cycle indicators / Base-cases		EPS for			
	Unit	Mobile phone	Digital camera	Laptop (–PFC)	Laptop (+PFC)
Total Energy (GER)	MJ	95	83	1723	2364
of which, electricity	MJ	31,0	10,7	1612,7	2211,1
Water (process)	ltr.	4	3	114	153
Waste, non-haz./ landfill	g	269	574	2889	3874
Waste, hazardous/ incinerated	g	48	57	159	247
Emissions (Air)					
Greenhouse Gases in GWP100	kg CO_2eq.	6,6	6,2	78,5	106,9
Acidifying agents (AP)	g SO_2eq.	27,5	28,4	461,8	629,0
Volatile Org. Compounds (VOC)	g	0,1	0,1	1,0	1,4
Persistent Org. Pollutants (POP)	ng i-Teq.	0,7	0,5	11,7	15,9
Heavy Metals (HM)	mg Ni eq.	5,3	5,7	38,4	50,0
PAHs	mg Ni eq.	4,3	6,5	20,1	35,3
Particulate Matter (PM, dust)	g	5,3	6,6	25,2	39,4
Emissions (Water)					
Heavy Metals (HM)	mg Hg/20	1,6	3,4	17,9	26,4
Eutrophication (EP)	g PO_4	0,1	0,1	0,3	0,4
Lot 7 LCC new product					
Product price	€	3,68	6,83	31,50	31,50
Electricity	€	0,31	0,09	17,87	24,75
TOTAL consumer expenditure	€	3,98	6,92	49,37	56,25

7.2.8 OPTION 5: MICROPROCESSOR CONTROLLED CHARGER

Replacing slow/overnight charger by microprocessor controlled chargers is considered an environmentally preferred option for standard battery chargers and professional power tools (although it is actually already implemented usually in professional power tools), but not for DIY power tools, where the rare use is offset by the additional manufacturing efforts. As, on average, the batteries of DIY tools go through only very few charging cycles, protecting the batteries with appropriate control of the charging process is not necessary.

For standard battery chargers, microprocessor controlled designs do not have an LCC benefit at all, as the assumed price difference (10 Euro vs. 35 Euro – see the market analysis) cannot be offset by energy savings or battery life savings.

7.2.9 OPTION 6: LIFETIME EXTENSION – STANDARDISATION OF INTERFACES

The impacts of interface standardisation depend on various factors as explained in detail in section 7.1. For the EcoReport calculation, a potential of twice the lifetime is assumed (using one EPS for two consecutive product generations or for two devices in parallel) for all external power supplies. Compared to the base-cases, the only adjustment is the lifetime entry.

Note: The data provided below in Table 7-21 is based on half product each to take into account the doubled lifetime.

Table 7-21 – EIA and LCC for Implementation of Option 6

Lot 7 Total environmental impacts (normalisation: half product life)		EPS for								
Main life cycle indicators / Base-cases	Unit	Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (-PFC)	Laptop (+PFC)	Power tool charger
Total Energy (GER)	MJ	99,1	727,2	81,4	664,0	361,2	599,6	2374,8	3152,4	225,9
of which, electricity	MJ	61,6	645,8	44,4	556,5	326,6	549,0	2316,3	3070,6	105,2
Water (process)	ltr.	163,1	1734,6	118,7	1514,7	867,8	1457,6	6158,0	8196,3	259,1
Waste, non-haz./ landfill	g	198,0	994,6	360,7	850,2	564,6	873,2	3248,7	4285,1	645,5
Waste, hazardous/ incinerated	g	31,6	83,9	32,4	115,7	37,9	78,0	120,9	179,5	193,9
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO_2eq.	5,6	33,7	4,8	31,2	17,1	27,7	105,4	139,5	12,5
Acidifying agents (AP)	g SO_2eq.	27,4	192,7	25,0	175,8	95,8	160,6	621,6	823,1	78,1
Volatile Org. Compounds (VOC)	g	0,1	0,6	0,1	0,6	0,2	0,4	1,1	1,4	0,6
Persistent Org. Pollutants (POP)	ng i-Teq.	0,7	4,7	0,5	4,2	2,4	3,9	15,8	20,9	1,6
Heavy Metals (HM)	mg Ni eq.	3,7	15,0	3,7	13,7	8,5	13,5	45,6	59,2	12,0
PAHs	mg Ni eq.	4,2	21,8	3,5	31,2	3,3	7,9	13,8	23,1	28,1
Particulate Matter (PM, dust)	g	4,1	15,6	3,9	20,6	5,2	10,3	21,7	31,9	25,3
Emissions (Water)										
Heavy Metals (HM)	mg Hg/20	1,6	9,3	2,1	10,6	3,3	5,6	19,1	26,5	8,6
Eutrophication (EP)	g PO_4	0,0	0,1	0,0	0,1	0,1	0,1	0,2	0,3	0,4
Lot 7 LCC new product (normalisation: half product life)										
Product price	€	1,75	1,75	3,25	3,25	1,75	6,25	15,00	15,00	9,75
Electricity	€	0,65	6,19	0,47	6,16	3,39	5,68	23,06	30,69	0,83
TOTAL consumer expenditure	€	2,40	7,94	3,72	9,41	5,14	11,93	38,06	45,69	10,58

7.2.10 OPTION 2+6: IMPLEMENTATION OF TECHNICAL OPTIONS LISTED IN SECTIONS 7.1.2, 7.1.4 TO 7.1.10 AND LIFETIME EXTENSION

Table 7-22 provides EIA and LCC for a combination of options 2 and 6: Implementation of technical options listed in sections 7.1.2, 7.1.47.1.10 including change-over from linear to switch-mode products and lifetime extension by standardisation of interfaces. Option 6 could also be combined with the options 3 and 4, but such a combination is not analysed here.

Table 7-22 – EIA and LCC for Implementation of Option 2+6

Lot 7 Total environmental impacts (normalisation: half product life)		EPS for								
Main life cycle indicators / Base-cases	Unit	Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (-PFC)	Laptop (+PFC)	Power tool charger
Total Energy (GER)	MJ	96,0	461,1	81,0	592,1	334,3	516,0	1792,1	2420,2	198,0
of which, electricity	MJ	63,4	428,2	44,0	541,4	299,7	465,4	1733,6	2338,4	77,3
Water (process)	ltr.	5,6	29,9	4,0	39,8	21,8	34,7	119,2	159,0	15,6
Waste, non-haz./ landfill	g	200,2	623,3	360,3	864,4	533,4	776,3	2573,1	3436,2	613,1
Waste, hazardous/ incinerated	g	27,4	35,8	32,3	77,9	37,3	76,1	107,4	162,6	193,2
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO_2eq.	5,5	21,4	4,8	27,4	15,9	24,1	79,9	107,6	11,3
Acidifying agents (AP)	g SO_2eq.	26,5	120,5	24,9	158,7	88,9	139,1	471,6	634,6	70,9
Volatile Org. Compounds (VOC)	g	0,1	0,2	0,1	0,4	0,2	0,3	0,9	1,2	0,0
Persistent Org. Pollutants (POP)	ng i-Teq.	0,7	3,0	0,5	3,9	2,3	3,4	11,9	16,1	1,4
Heavy Metals (HM)	mg Ni eq.	3,6	9,9	3,7	13,4	8,1	12,1	35,6	46,7	11,6
PAHs	mg Ni eq.	2,3	3,0	3,5	7,9	3,2	7,7	12,7	21,7	28,1
Particulate Matter (PM, dust)	g	3,2	5,3	3,9	10,2	5,0	9,8	18,5	27,9	25,1
Emissions (Water)										
Heavy Metals (HM)	mg Hg/20	1,2	3,5	2,1	5,6	3,1	5,1	15,3	21,8	8,4
Eutrophication (EP)	g PO_4	0,0	0,1	0,0	0,1	0,1	0,1	0,2	0,2	0,4
Lot 7 LCC new product (normalisation: half product life)										
Product price	€	1,84	1,84	3,41	3,41	1,84	6,56	15,75	15,75	10,73
Electricity	€	0,67	4,07	0,47	5,87	3,11	4,81	17,23	23,36	0,55
TOTAL consumer expenditure	€	2,50	5,91	3,88	9,28	4,95	11,37	32,98	39,11	11,28

7.2.11 OPTION 7: BEST AVAILABLE TECHNOLOGY / "BEST IN CLASS"

The "Best in class" can reliably take into account only data on energy efficiency and no-load, as BOM tends to become leaner (in terms of weight mainly), but the actual data is not known, and purchasing prices cannot be stated.

For the calculations, the BOM of option 2 will be taken as orientation. As a likely overestimate purchasing prices of +50% will be assumed[61].

Table 7-23 – EIA and LCC for Implementation of Option 7

Lot 7 Total environmental impacts PER PRODUCT											
Base-cases / Main life cycle indicators		EPS for								Transformer for halogen lighting	
	Unit	Mobile phone	DECT phone	Digital camera	Set-top box / modem	Personal care appliance	Printer	Laptop (–PFC)	Laptop (+PFC)	(Magnetic)	(Electronic)
Total Energy (GER)	MJ	125	497	99	461	278	400	1434	1825		899
of which, electricity	MJ	59,6	430,8	25,4	360,1	209,1	299,0	1317,3	1661,7		769,1
Water (process)*	ltr.	7	31	4	31	17	27	95	117		58
Waste, non-haz./ landfill	g	322	753	648	891	614	820	2654	3377		1339
Waste, hazardous/ incinerated	g	53	62	63	139	66	138	165	256		135
Emissions (Air)											
Greenhouse Gases in GWP100	kg CO_2eq.	8,0	24,2	6,9	23,2	14,8	20,6	66,0	83,6		42,6
Acidifying agents (AP)	g SO_2eq.	35,7	131,4	33,7	131,2	77,3	115,5	389,5	492,8		241,1
Volatile Org. Compounds (VOC)	g	0,1	0,3	0,2	0,5	0,2	0,5	0,9	1,2		0,7
Persistent Org. Pollutants (POP)	ng i-Teq.	0,9	3,3	0,7	3,0	1,9	2,6	9,8	12,4		6,2
Heavy Metals (HM)	mg Ni eq.	6,0	12,4	6,2	14,4	9,4	13,3	34,3	41,6		20,3
PAHs	mg Ni eq.	4,5	5,2	6,9	14,3	5,6	14,2	21,2	37,4		30,9
Particulate Matter (PM, dust)	g	6,0	8,2	7,4	16,5	7,9	16,1	25,2	39,2		20,1
Emissions (Water)											
Heavy Metals (HM)	mg Hg/20	1,9	4,3	3,8	6,5	3,7	6,1	16,8	24,2		11,9
Eutrophication (EP)	g PO_4	0,1	0,1	0,1	0,3	0,1	0,3	0,3	0,4		0,2
*=caution: low accuracy for production phase											
Lot 7 LCC new product											
Product price	€	5,25	3,68	9,75	9,75	5,25	18,75	45,00	45,00		40,00
Electricity	€	0,64	4,66	0,26	4,10	2,34	3,30	14,54	18,58		7,67
TOTAL consumer expenditure	€	5,89	8,34	10,01	13,85	7,59	22,05	59,54	63,58		47,67

For the DECT phone segment, the given efficiency is already achieved by the option 2 variant, no-load losses do not matter for DECT-phones, the cost data therefore remains unchanged.

61 But this is not an assumption confirmed by industry (yet), rather guess work to get an impression of correlations

7.2.12 LEAST LIFE CYCLE COSTS AND BEST AVAILABLE TECHNOLOGY

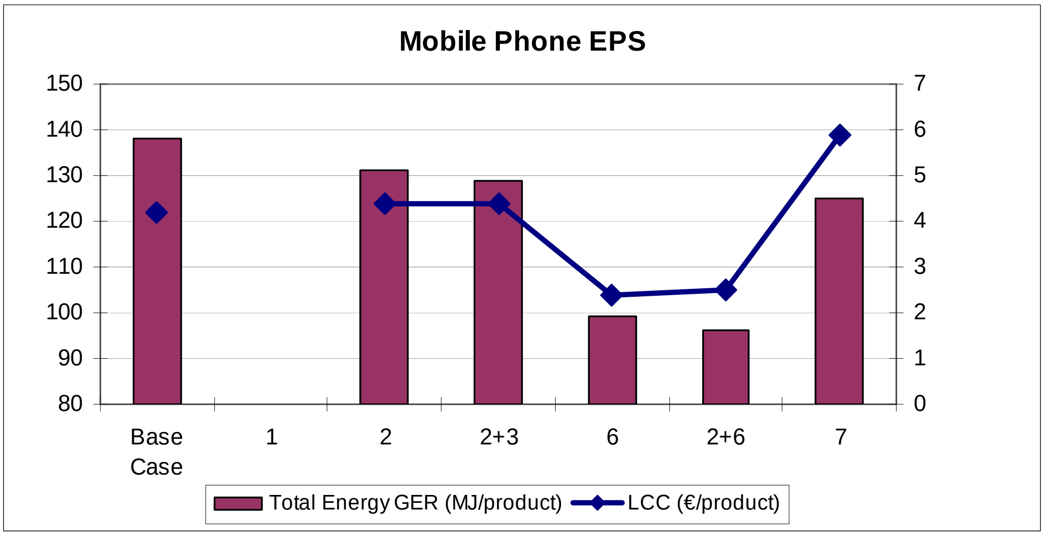
The graphs below show the results of the environmental assessments for individual key end-applications with total energy (GER) on the left Y-axis as key environmental parameter. For other environmental parameters the trend might be different. It should be noted that the GER scale has different starting unit for each graph to give a better impression on the differences among the options. When interpreting the graphs below, the various uncertainties, restrictions and assumptions made throughout the study should be kept in mind.

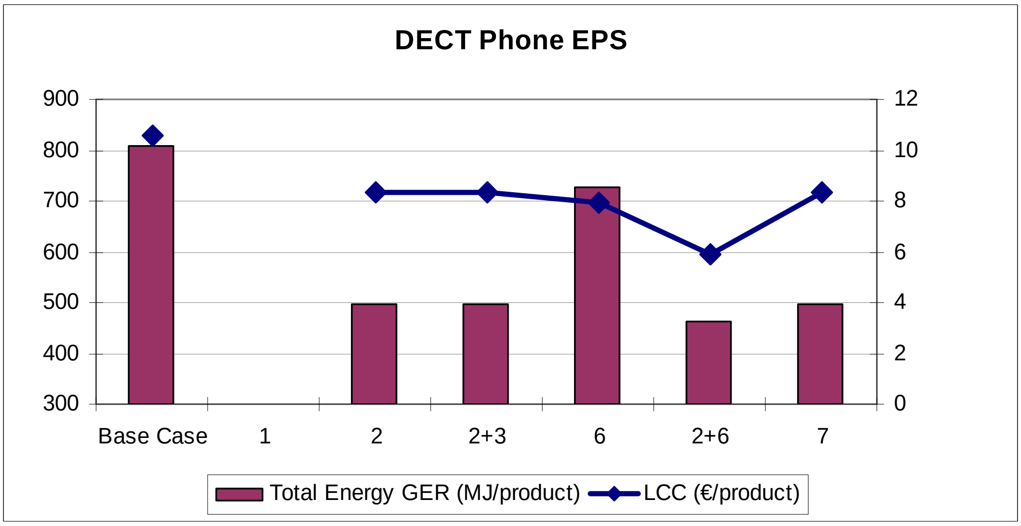
The graphs allow conclusions only per product, not in the light of the overall stock of products from the scope of this study. See task 5 where a comparison of the stock per base case is provided for general significance of the different base cases.

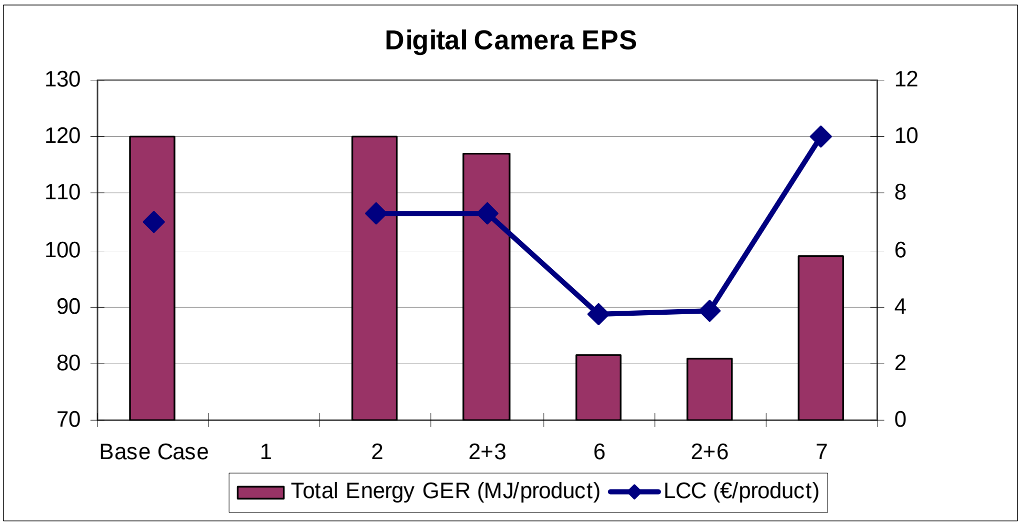
The point of Least Life Cycle costs for the external power supplies (halogen lighting transformers excluded) is mostly option 2+6, implementation of various technical improvement options on the circuitry level in conjunction with lifetime extension through standardisation of interfaces.

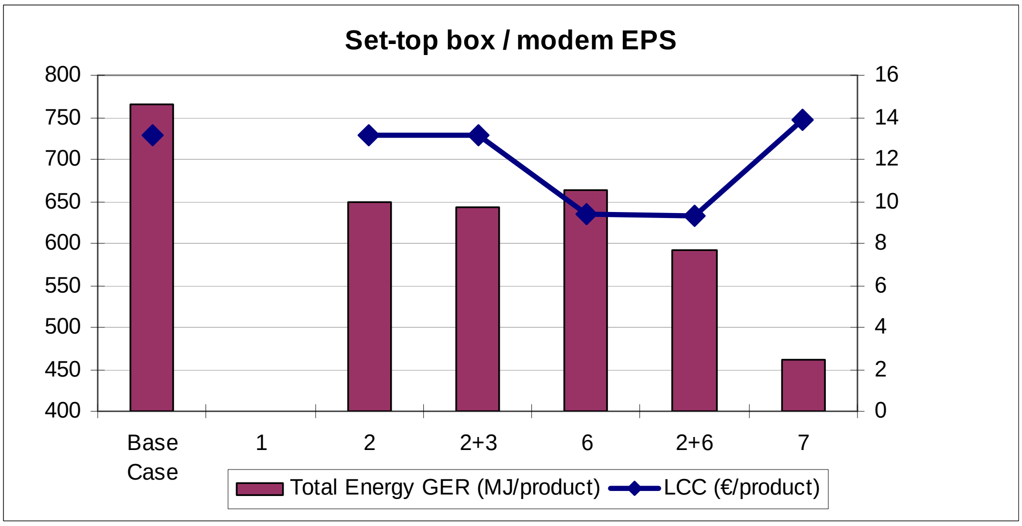
Additional, but minor improvements are achievable when considering also the differences regarding resource consumption and production impacts (option 3: improved BOM / size reduction).

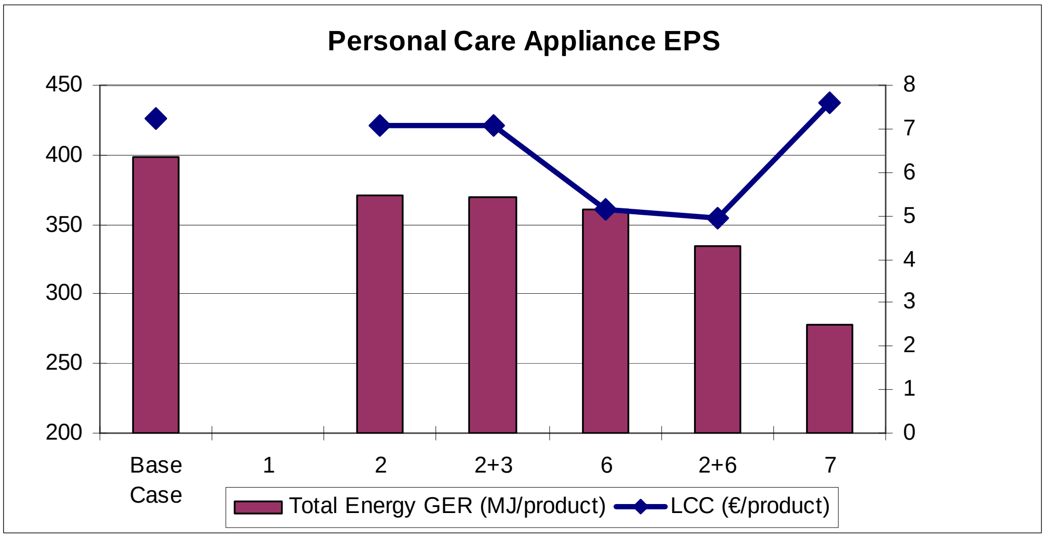
Regarding BAT, i.e. best in class option (option 7), it is important to notice that the graphs have these BATs only as stand-alone option and not in combination with additive options (3, 6), which gives in some cases the misleading impression that BAT results in adverse environmental impacts, which is not the case: Option 7 rather has to be seen in comparison to option 2. In case the assumed costs for the "best in class" products (+50%) can be confirmed or are even less, option 7 in conjunction with other measures (e.g. option 4, 6) could lead to life cycle costs even lower than the current life cycle costs.

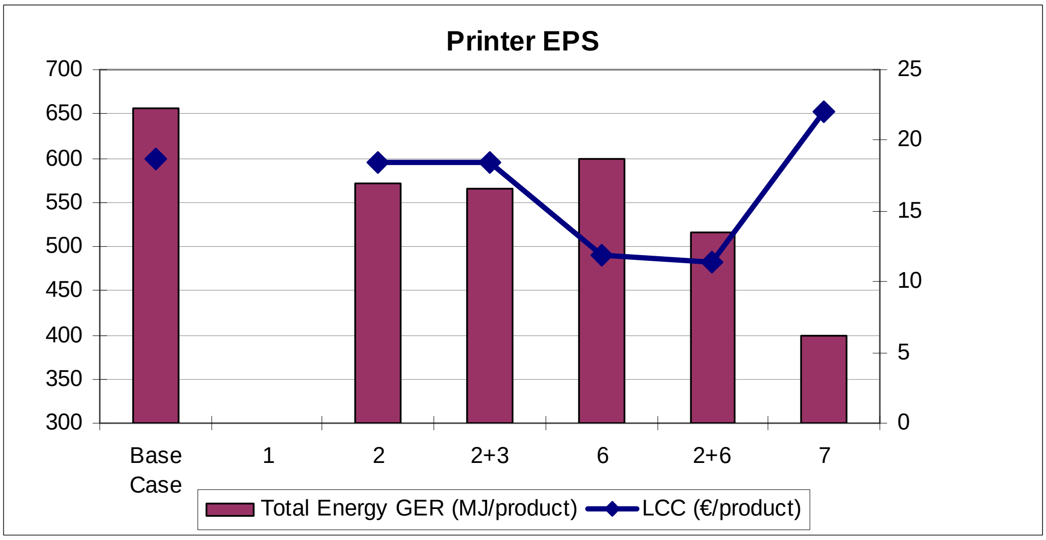


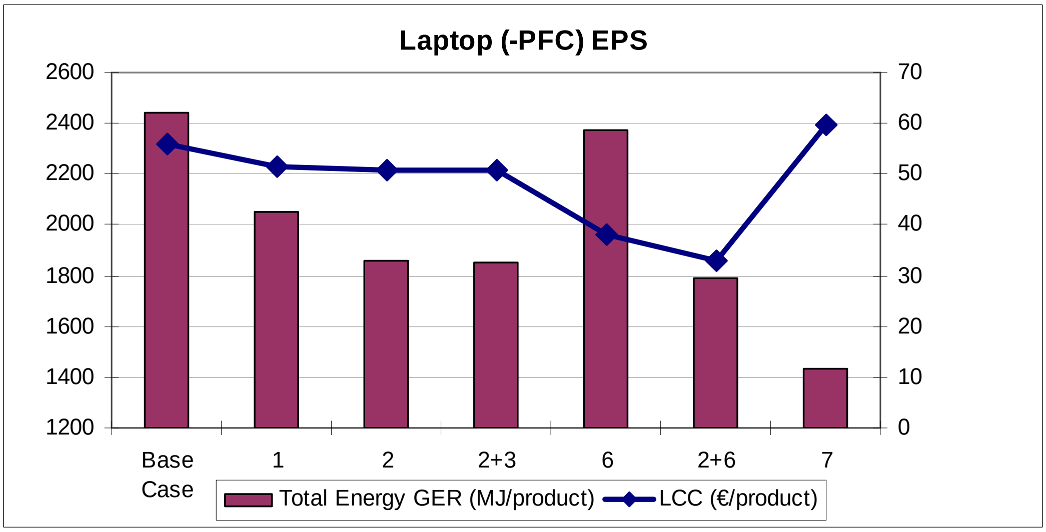

DECT Phone EPS
900
800
700
600
500
400
300
12
10
8
6
4
2
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)

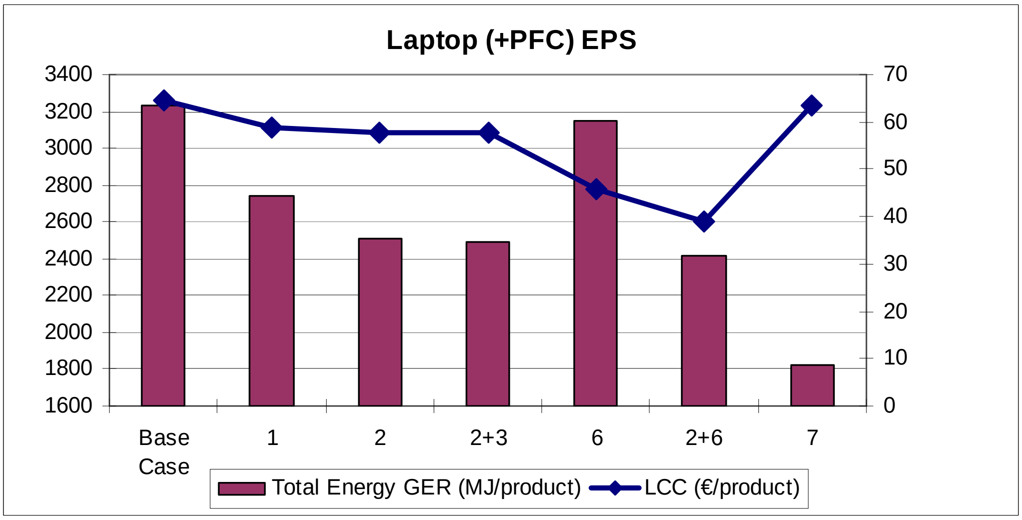

Digital Camera EPS
130
120
110
100
90
80
70
12
10
8
6
4
2
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)


Set-top box / modem EPS
800
750
700
650
600
550
500
450
400
16
14
12
10
8
6
4
2
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)

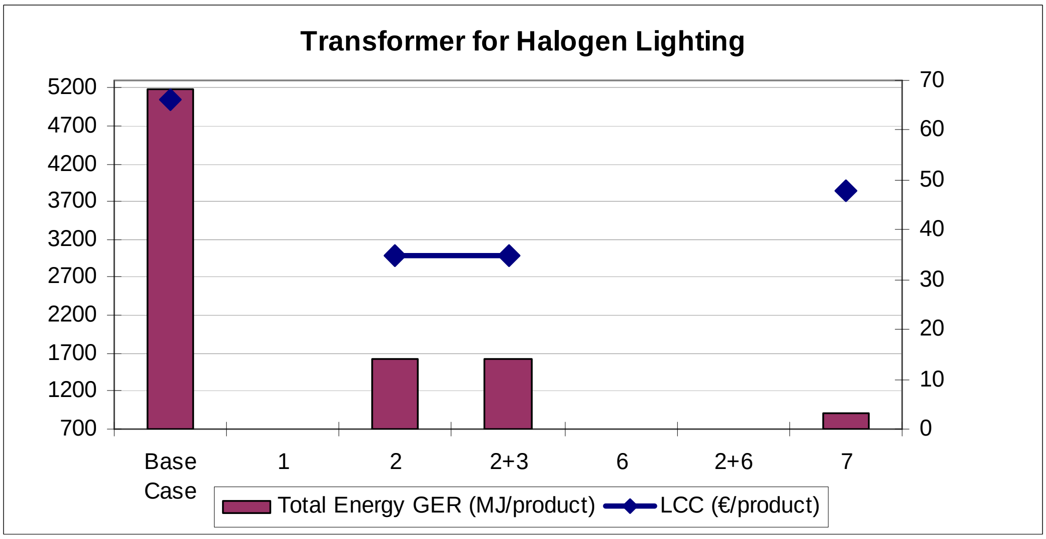

Personal Care Appliance EPS
450
400
350
300
250
200
8
7
6
5
4
3
2
1
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)


Printer EPS
700
650
600
550
500
450
400
350
300
25
20
15
10
5
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)

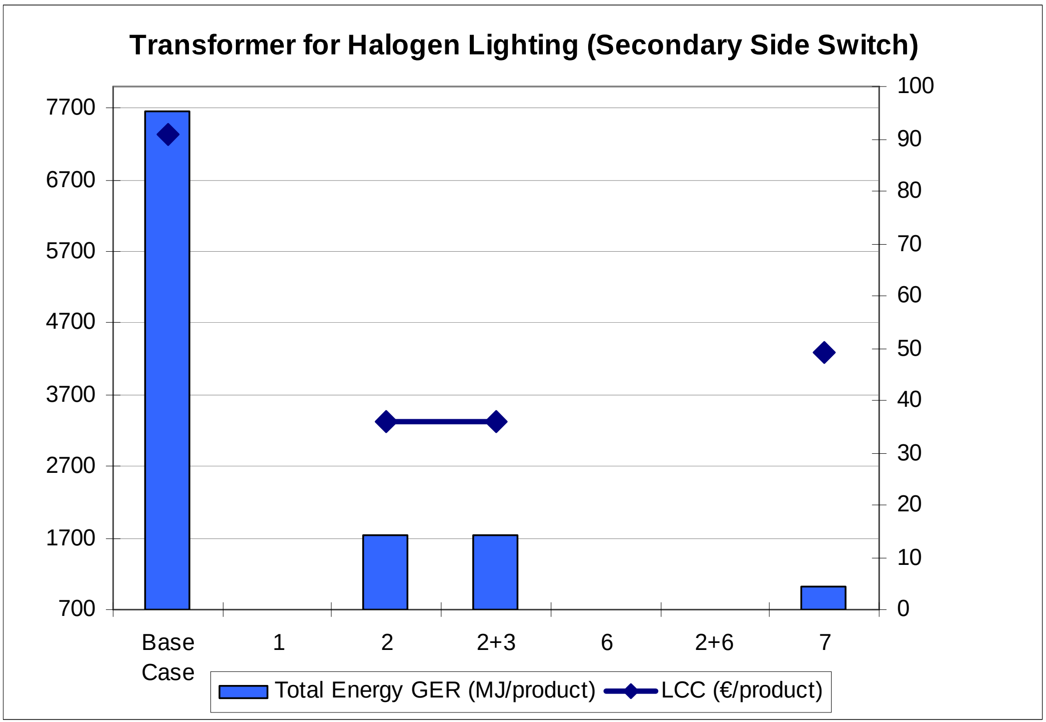

Laptop (-PFC) EPS
2600
2400
2200
2000
1800
1600
1400
1200
70
60
50
40
30
20
10
0
Base Case
1
2
2+3
6
2+6
7
Total Energy GER (MJ/product)
LCC (€/product)



For halogen lighting transformers the graph below shows the base-case for magnetic transformers and for the improvement options the electronic transformer alternatives (scenario with primary side switch only). Clearly, the change from magnetic to electronic (option 2) is a significant environmental improvement and leads also to mayor cost savings. This difference is even larger for the alternative scenario with secondary side switch (and no-load losses). The "best in class" approach can even achieve nearly a further 50% reduction of total energy consumption. The best performing electronic halogen lighting transformers (option 7) are located beyond the point of LLCC, but are still less costly than magnetic ones.



For comparison the graph below shows the results for the scenario with secondary side switch and no-load losses. Option 7 has been calculated with the same no-load losses of 0.2 W as the option 2.



For standard battery chargers no graph is shown as the pre-calculations (as explained above) led to the conclusion that the option of microprocessor controlled chargers in general is too costly in terms of LCC. Influencing consumer behaviour to reduce no-load losses seems to be the major effective option at the moment, but rather a question of consumer awareness than a real technical option - especially as nearly all chargers on the market already have an indicator for the full charging state. However, it may be argued that a mass market for microprocessor controlled chargers could bring prices down considerably as these products would become “the standard”.

Chargers for cordless power tools have a potential for improvements of approximately 10-15% compared to the base-case, but technical options to lower energy consumption in the different use modes (option 2) do not lead to lower life cycle costs, which are actually slightly increasing.

Theoretically, the consumer is likely to benefit from lower life cycle costs for the option of lifetime extension of the charger (options 6 and 2+6). Nevertheless, there are major constraints to the lifetime extension by standardisation of connectors/interfaces/batteries for cordless power tool chargers, as outlined in section 7.1.12. Indeed, the life cycle cost calculations do not include costs of malfunction that may result from the user manipulated charger-battery-systems, which may occur when power tools are sold without chargers. “The option of standardisation of chargers was already considered by the worldwide cordless power tools industry in the early nineties but the idea was abandoned for major safety reasons”[62].

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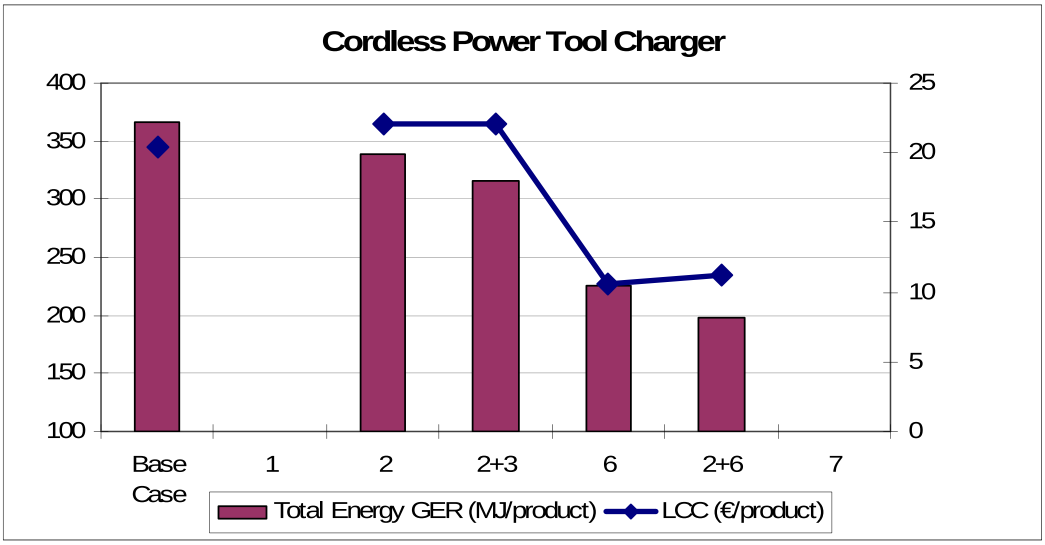
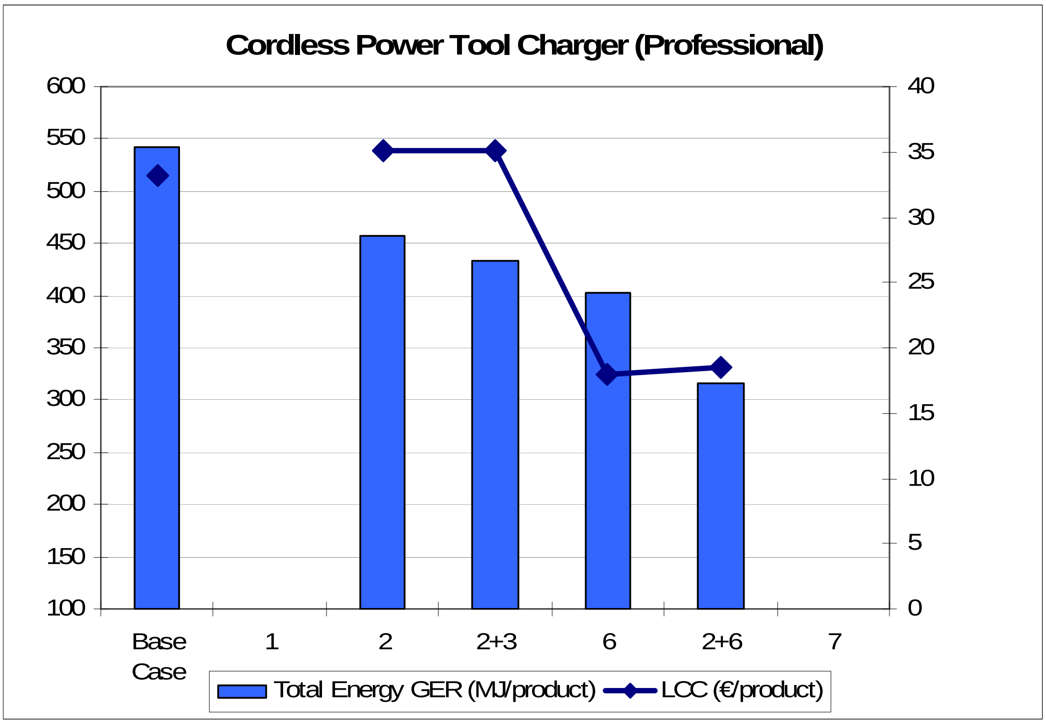
62 Stakeholder comments from RECHARGE (January 10th, 2007)

The chart below shows the results for average of professional and DIY power tools.



As use patterns for professional and DIY tools and chargers differ significantly, the chart below shows the results for professional power tool chargers explicitly: Although power consumption for these is much higher due to the high number of charging cycles the achievable technical improvements do not lead to savings in LCC. The increased purchase price nullifies electricity savings although the lifetime of the professional tools / chargers is much lower (2 years compared to 7 years for DIY tools). Nevertheless, achievable power savings are significant (minus 15% total energy consumption).



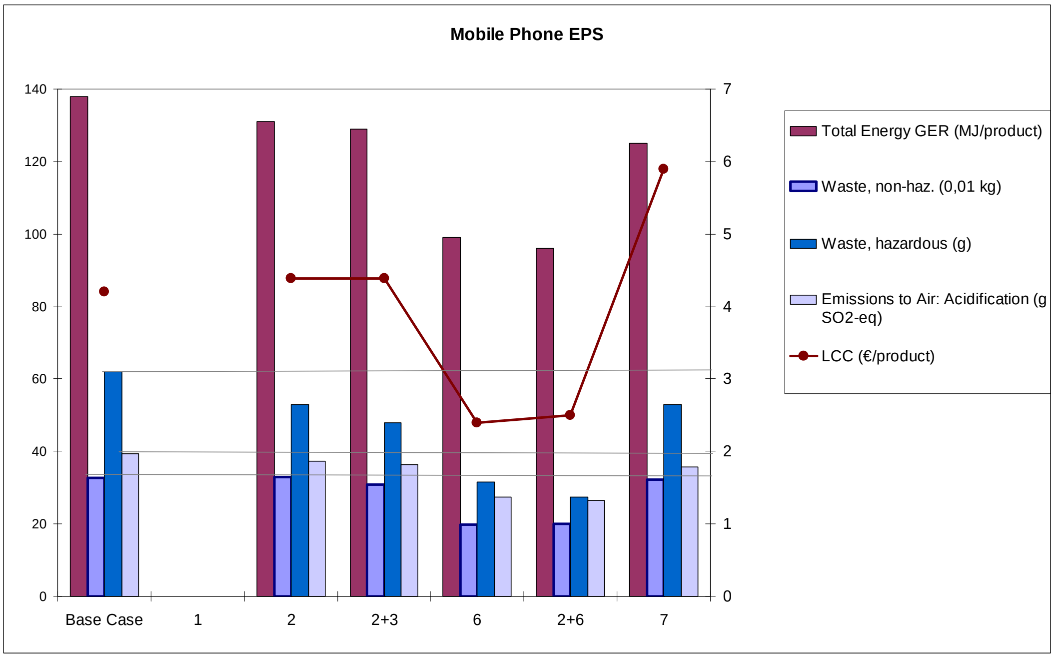
For DIY tool chargers no detailed analysis is given, but due to the very limited number of charging cycles, reductions in power consumption have a very minor effect and life cycle costs are dominated by increase in purchase price.

Cross-check with other environmental indicator categories

As the graphs above refer to the category total energy only, a cross-check is required, if the trends are the same for other indicators as well. The graph below exemplarily for the case of mobile phone EPS addresses the indicator categories

- Total Energy GER
- Waste, non-hazardous
- Waste, hazardous
- Emissions to Air: Acidification

Comparing the options with each other, the trends are basically the similar for the different categories, meaning for the options discussed, total energy can serve as key environmental parameter.



7.3. LONG-TERM TARGETS (BNAT) AND SYSTEMS ANALYSIS

The long-term evolution of EPS/BC sector will depend on the technological development and evolution of the following four aspects:

- End-applications (from the systems analysis perspective)
- Alternative power supply mechanisms in the existing system (Ethernet, USB, etc.)

- Other energy sources external to the system (solar chargers, fuel cells, etc.)
- EPS/BC themselves

While the first issue will influence the power needs (increase/decrease) of the future, the second and third issues will provide alternative means to fulfil those needs, and the last aspect (which is the focus of this study) will affect indirectly the energy consumption through the efficiency by which this energy will be transformed, depending upon the demand and supply.

In the long term, these three aspects need to go hand in hand to optimise the power demand-supply chain for this product segment. The consumer behaviour aspect lies above all of them and the end-user will have a very significant role in such optimisation.

One of the most important trends to be followed is the evolution of end-applications which will dictate the energy demand of the future and the means to fulfil it (e.g. internal vs. external power supplies). If we look at recent trends, taking the example of “I-Pod”, the evolution has been towards smaller sizes and lighter models (very closely linked to the consumer preferences). Whereas the older and bulky versions were more power hungry and thus always supplied with an EPS for charging purpose, for the more recent ones (i-pod mini and nano), the EPS is optional. Due to their efficient design and low power needs, a fast charging is possible through the USB port of the computer. Similarly, a great deal of computer peripherals in the long run may converge to the computer itself for their power needs rather than having an individual external power supply. An example to demonstrate such trends are scanners where most of the portable scanners sold today do not need an EPS contrary to the practice a couple of years ago. This trend may further extend to products such as digital cameras, mobile phones, etc. where more and more interaction with the information technology can be expected to happen in the long-term future.

There will still be some sectors (power tools, personal care products, etc.) where the inherent need for an external energy source will continue to exist and in such case the key issues to address will be

- To design end applications for lower consumption through an efficient use of energy
- To improve the performance of renewable or alternative energy supply resources (and at a lower cost)
- To perform more efficient energy transformation in the EPS/BC

The market trends (Task 2) and the technology trends (Task 6) clearly demonstrate an evolution in this direction and an environmentally conscious consumer can accelerate this process further to bring about the maximum energy savings by avoidance of no-load losses.

8. SCENARIO-, POLICY-, IMPACT-, AND SENSITIVITY ANALYSIS

The objective of the task 8 is to put the results of this preparatory study in the overall policy context of the EuP Directive. It has to be kept in mind that the conclusions drawn here are preliminary and represent solely the consortium point of view and they do not reflect the opinion of the European Commission in any way. Unlike task 1-7 reports, which will serve as the baseline data for the future work (impact assessment, further discussions in the consultation forum, and development of implementing measures, if any) conducted by the European Commission, the task 8 simply serves as a summary of policy implications as seen today. Further, some elements of this task will be analysed again in a greater depth during the impact assessment.

8.1. SCENARIO ANALYSIS

Different scenarios 1995-2020 are drawn up to illustrate quantitatively the improvements that can be achieved at EU level by 2020 with suitable policy means. The Business-as-Usual scenario will serve as a reference. These scenarios are based on following common assumptions.

- The sales and stock data are projected at the aggregated level. The growth rate for individual product segments is not estimated. The compound annual growth rate for external power supplies/battery chargers for the period 2005-2010 is considered to be 9.4% (source: Darnell Group) and 5% for the period 2010-2020 assuming that the application market will saturate and alternate and/or efficient means of power supply will gain importance.

- The average product life is assumed to be 4 years and thus stock at any given year is a summation of last 4 years sales, except for halogen lighting for which 10-year lifetime is assumed.

- For the Least Life Cycle Cost (LLCC) comparison purposes, battery chargers are excluded from the totals because the none of the proposed technical improvement options lead to LLCC for these products. Hence for comparison sake, these products are excluded also from the Business-as-usual scenario.

- For the consumer expenditure the electricity price (0.136 euros/KWh) is assumed to constant in the future which is unlikely to be true but it depends on many external factors and detailed energy forecasting is required to assume some realistic values. The product prices, however, are assumed to decrease because of the lower material consumption and better fabrication technologies available in the future.

8.1.1 SCENARIO DEVELOPMENT

Following three scenarios have been analysed and compared. For each scenario, the aggregated impacts (environment, energy, and costs) are calculated for 2005 and projected for 2010, 2015, and 2020. The final results are presented graphically at the end of this sub-section.

- **Scenario 1**: Business-as-Usual

  This scenario projects the consumption of energy and Life Cycle Costs (LCC) of the Lot 7 stock based on today's average performance (base-cases) and using a variable stock size. It should be noted that this is not a real-life scenario but rather a worst case. The products are likely to evolve even if EuP Directive implementing measures are not in place. Legislation in other countries (e.g. California) is currently pushing the global market to a more efficient direction, for example laptop EPS which have more or less similar specifications in the US and Europe. Also, voluntary initiatives in Europe such as the Code of conduct and ENERGY STAR are bound to improve these products. However, any such improvements are not considered while constructing this scenario.

Data	**Unit**	**Aggregated lot 7 for**			
		2005	**2010**	**2015**	**2020**
Sales	Millions	506	782	992	1261
Stock	Millions	2000	2876	3819	4819
Total Energy (GER)	PJ	248	334	426	523
Electricity	TWh	19	25	32	39
Water (process)	Mln.m^3	15	20	26	32
Waste, non-haz./ landfill	Kton	415	574	745	926
Waste, hazardous/ incinerated	Kton	50	71	94	118
Emissions (Air)					
Greenhouse Gases in GWP100	mt CO_2eq.	12	17	21	26
Acidifying agents (AP)	kt SO_2eq.	68	91	117	144
VOC	Kt	0	0	0	0
POP	g i-Teq.	2	2	3	3
Heavy Metals (HM)	ton Ni eq.	7	9	12	15
PAHs	ton Ni eq.	9	12	16	20
Particulate Matter (PM, dust)	Kt	7	10	14	17
Emissions (Water)		0	0	0	0
Heavy Metals (HM)	ton Hg/20	4	5	7	8
Eutrophication (EP)	kt PO_4	0	0	0	0
Consumer Expenditure					
Total consumer expenditure	M Euros	5681	7828	10141	12592

- **Scenario 2**: Staged minimum performance requirement (corresponding to LLCC based on current technologies, see section 7.2.12); this is a realistic short term (2010) policy scenario.

  This scenario assumes that LLCC option will be obligatory from 2010 onwards, i.e. 100% of the sales that year and beyond, will achieve LLCC performance. Until 2010, the environmental impacts and the LCC are based on today's average performance and the size of stock at reference years. Consequently, the stock of 2010 will be a mixture of non-LLCC and LLCC products, while 2020 stock will be 100% LLCC products - lifetimes are inferior to 10 years and product re-design cycles are reasonably short (see Box 8-1).

Data	**Unit**	**Aggregated lot 7 for**			
		2005	**2010**	**2015**	**2020**
Sales	Millions	506	782	992	1261
Stock	Millions	2000	2876	3819	4819
Total Energy (GER)	PJ	248	315	353	428
Electricity	TWh	19	24	26	31
Water (process)	$Mln.m^3$	15	19	22	27
Waste, non-haz./ landfill	Kton	415	556	676	833
Waste, hazardous/ incinerated	Kton	50	68	83	103
Emissions (Air)					
Greenhouse Gases in GWP100	mt CO_2eq.	12	16	18	22
Acidifying agents (AP)	kt SO_2eq.	68	86	98	119
VOC	Kt	0	0	0	0
POP	g i-Teq.	2	2	2	3
Heavy Metals (HM)	ton Ni eq.	7	9	11	13
PAHs	ton Ni eq.	9	11	11	13
Particulate Matter (PM, dust)	Kt	7	10	11	14
Emissions (Water)					
Heavy Metals (HM)	ton Hg/20	4	5	5	6
Eutrophication (EP)	kt PO_4	0	0	0	0
Consumer Expenditure					
Total consumer expenditure	M Euros	5681	7704	9684	11840

- **Scenario 3**: Enhanced market penetration of best performing products (regarding energy performance); this is a long-term (2020) maximum theoretical improvement potential scenario.

  For this scenario, it is assumed that the market share of BAT using products will be 30% in 2010 and 70% of them will be still using LLCC option. In 2015 this ratio will be 50-50 while in 2020 all the sales and stock are assumed to be BAT, as the options identified in this study are technically and economically feasible. Relatively short lifetimes of the Lot 7 products (except halogen lighting transformers) imply that any policy measures are likely to translate in few years into qualitative changes in products on the market.

Data	**Unit**	**Aggregated lot 7 for**			
		2005	**2010**	**2015**	**2020**
Sales	Millions	506	782	992	1261
Stock	Millions	2000	2876	3819	4819
Total Energy (GER)	PJ	248	309	325	334
Electricity	TWh	19	23	24	23
Water (process)	$Mln.m^3$	15	19	20	21
Waste, non-haz./ landfill	Kton	415	547	639	715
Waste, hazardous/ incinerated	Kton	50	67	80	94
Emissions (Air)					
Greenhouse Gases in GWP100	mt CO_2eq.	12	15	17	18
Acidifying agents (AP)	kt SO_2eq.	68	85	90	94
VOC	Kt	0	0	0	0

POP	g i-Teq.	2	2	2	2
Heavy Metals (HM)	ton Ni eq.	7	9	10	11
PAHs	ton Ni eq.	9	11	10	10
Particulate Matter (PM, dust)	Kt	7	10	10	12
Emissions (Water)					
Heavy Metals (HM)	ton Hg/20	4	5	5	5
Eutrophication (EP)	kt PO_4	0	0	0	0
Consumer Expenditure					
Total consumer expenditure	M Euros	5681	7701	10102	13808

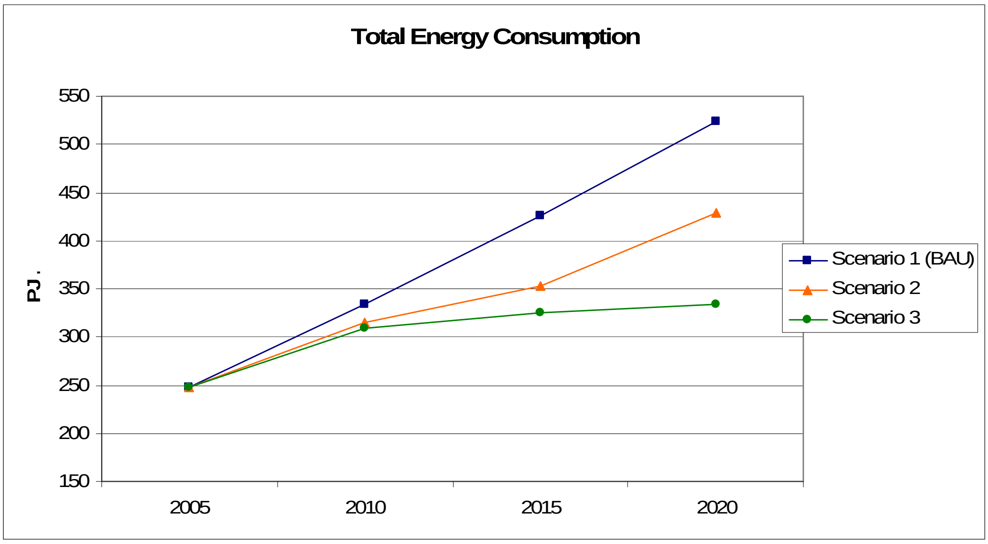
Box 8-1 – EPS and BC redesign cycles

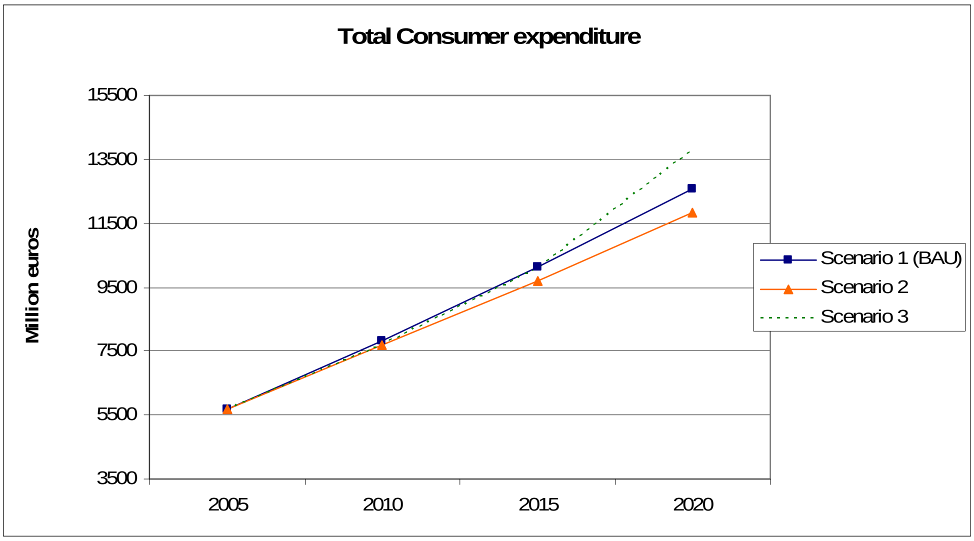
The product redesign cycle is a key term related to the EuP, but has not been defined as such, in this context. Regarding EPS and BC, at least two different definitions/approaches can be used, which lead to different redesign cycle times.

Redesign definition / approach	**Redesign cycle time***
Change of the product design, *based on available technologies* (available in-house or through solution providers), including redesign of the PWB layout, IC redesign, and change of components (suppliers)	Time from getting the requirement / decision to change the design to the point, when all “old” products are put on the market and only redesigned products will be sold: **6-22 months**
For OEM products: How frequently is the specification changing according to redesign of the end device (EPS redesign cycle depending on end device redesign cycle)	EPS specification for this OEM product type changes every **12-48 months**
* Redesign cycle times are based on the responses by 10 manufacturers/OEM in the context of this study.	

In principle, the term redesign cycle also depends on the level of redesign required: According to a transformer manufacturer, changing “only” some electronic components might be a project of 3 month, but as soon as the electronics design as such (rerouting of the printed circuit board, prototyping, testing etc.) is affected, this rather needs one year to be implemented.

In case a change from ac-ac to ac-dc power supplies is required (see below) also the redesign cycle of the end-device has to be taken into account, which could be – depending on the complexity of the end-device – even longer.





The reduced impacts (e.g. total energy consumption) of improved products are clearly visible when we move from BAU scenario to LLCC and BAT scenarios. The total consumer expenditure however should be interpreted carefully. For the scenario 3, assuming strong market penetration of BAT, total consumer expenditure is seen to increase. This is due to the higher price of BAT products (based on the current prices), which is not counterbalanced by the reduced electricity costs. However, in reality the prices of BAT products are expected to decline in the future as they become main stream products. Therefore, scenario 3 is likely to over estimate the adverse effects to the total consumer expenditure. Furthermore, all the future expenditure calculations will be influenced by the electricity prices in different MS in the coming years.

8.2. POLICY ANALYSIS

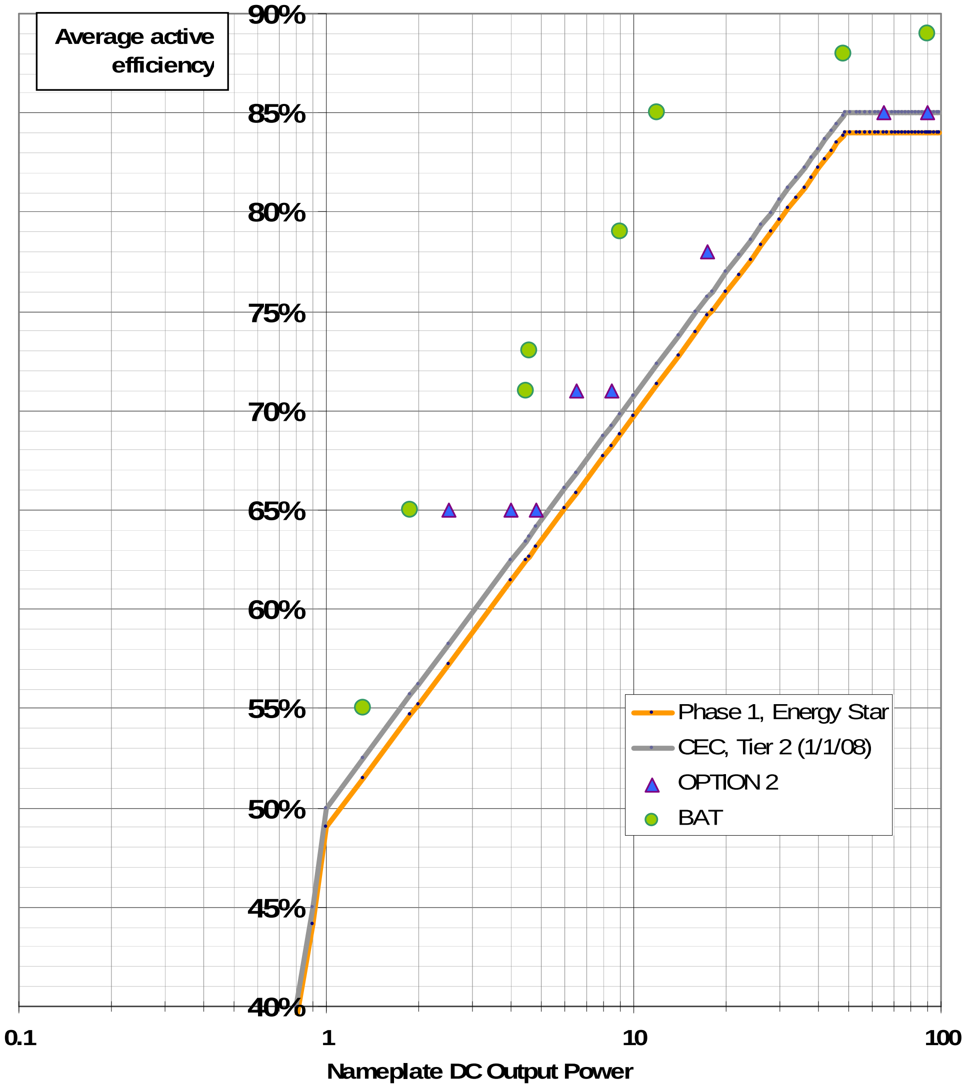
8.2.1 THRESHOLD VALUES

Considering the fact that a number of countries (including China) have set mandatory minimum energy performance requirements for EPS in recent years, this seems feasible for the European Union as well.

Acknowledging the fact that the major market players are international companies, they may have to comply with third country legislations. Further, the product specifications often being made for the worldwide market, these companies will also sell “compliant” products in the European market.

Based on the sub-task 1.3.3, it is clear that the many countries have made efforts to harmonise their obligatory and voluntary compliance levels. Figure 8-1 compares the ENERGY STAR (phase 1) and California Energy Commission (CEC) (tier 2) minimum energy efficiency requirements with the efficiencies of the improvement option 2 and BAT of this study.

Figure 8-1 – ENERGY STAR (phase 1), CEC (tier 2) as well as Lot 7 Option 2 and BAT average active efficiencies as a function of the nameplate DC output power



For the sake of harmonisation, CEC tier 2 requirements, which will be applied from 1 January 2008 onwards, appear relevant as short term targets. Stricter requirements especially in the low and mid power ranges could be mid- to long-term targets.

The general EPS conclusions are, in principle, also valid for medical equipment, which were not explicitly covered by the base-cases. However, the impacts of any implementing measures on industry are likely to be much higher due to low production numbers and high qualification costs. The qualification procedure also slows down the redesign process of existing products. A relaxed timeline regarding possible implementing measures may be justified for these products to allow them to be redesigned together with the main product's redesign cycle.

A requirement is recommended to make the measured efficiency data of the external power supplies public or at least to disclose these to the European Commission or a contractor of the European Commission to allow a thorough observation of future market developments, which will very helpful for any possible future review of a possible implementing measure.

8.2.1.1 EPS

As indicated by the market and technical analysis (base case calculations) low no-load losses are already achieved by a majority of EPS (e.g. lower than 0.5 W and 0.75 W for rated output up to 10 W and above 10 W respectively). To make these thresholds mandatory would not lead to improvements at large, but would (1) keep the few worst performers out of the market and (2) avoid design strategies among the manufacturers, which target at high efficiency only, which might result in increasing no-load losses. In the mid-term stricter no-load limits of 0.3 W for the low power segment and 0.5 W for the higher power segments (see option 2) seem to be reasonable. However, taking into account the calculation error margins it does not seem justified to set 0.3 and 0.5 W as limits in the short term as the technical analysis allows only the conclusion, that no-loads in the range of 0.3 W and 0.5 W can be achieved (but actually could be e.g. 0.32 W).

8.2.1.2 AC-AC Power Supplies

In case of efficiency thresholds for external power supplies in general (targeting at the major market of AC-DC power supplies), AC-AC power supplies are also able to meet these thresholds as they have step-down losses but not the rectification losses of AC-DC power supplies. However, no dedicated data is available on AC-AC power supplies to make a robust statement on which efficiencies are achievable for AC-AC power supplies.

The above mentioned requirement to disclose such efficiency data will allow a better assessment of the AC-AC market as such.

For the low power range, a no-load loss threshold of 0.5 W is hardly achievable for the majority of AC-AC EPS, but for example the toroidal transformers developed by PanPower (prototype status!) might be able to comply, whereas a threshold value of 0.3 W no-load losses is likely not to be achievable with current AC-AC EPS designs.

A threshold value of 0.5 W or even 0.3 W is likely to lead to a shift to AC-DC switch-mode power supplies (SMPS) where the electronic circuitry of the end-device runs on DC anyhow, such as DECT phones, modems, and routers. As the overall power supply system efficiency is higher for the external AC-DC SMPS compared to the combination of external (linear) AC-AC step down transformation and integrated rectification, this shift would have a beneficial effect in terms of environmental performance.

However, there are some products, where the electrical parts run on AC as well and switch over to AC-DC does not make sense, such as fairy lights.

There are some products, which, under normal use, are never under no-load, such as EPS for DECT phones. A no-load threshold for these kinds of products would not reflect real use patterns. Consequently it might be advisable to exclude such products from any no-load requirements. However, the exemption of certain AC-AC power supplies from no-load requirements based on these grounds would be an incentive to stay with the system of AC-AC EPS and internal rectification

8.2.1.3 HALOGEN LIGHTING TRANSFORMERS

Regarding halogen lighting transformers, this study focussed on external transformers only, but technical speaking these findings most likely can be applicable to halogen lighting transformers in general, including the internal ones.

Based on the BAT and LLCC considerations, a more stringent threshold for these transformers is recommended (compared to EPS in general) at 92.5 %, which can easily be met by most electronic transformers but not by the magnetic transformers.

With an efficiency limit, which allows (in correspondence with the LLCC considerations) only electronic transformers to remain in the market, the no-load losses will also be significantly lower. This is an inherent characteristic of electronic transformers compared to magnetic transformers: no loads below 0.5 W are easily achievable for electronic transformers. Therefore, it is not required to define a no-load threshold for halogen lighting transformers. However, if a limit for no-load is defined, it is recommended to exempt "halogen lighting transformers which are intended to be mounted on the secondary side of the mains switch", as this would minimise the compliance procedure for those products for which no-load condition is irrelevant.

8.2.1.4 BATTERY CHARGERS

The contribution of battery chargers to the environmental impacts and LCC of Lot 7 products is rather limited compared to EPS (see task 5). Thus development of performance requirements for battery chargers has a lower priority than for EPS and halogen lighting transformers.

Furthermore, with the "base case" approach, it has not been possible to properly address the broad spectrum of relevant BC parameters. In addition to the parameters common with EPS, the performance of a battery charger depends on a number of battery characteristics (such as the battery chemistry), but batteries were not covered by the scope of this study.

In general, there is a huge variety in efficiencies and no-load losses among standard battery chargers (see task 4), which leads to the recommendation that it should become mandatory as part of the eco-profile to declare the no-load consumption and the charging efficiency. However, the latter requires a standardisation that specifies how to measure and calculate the efficiency. An approach could be to measure for chargers, which are sold with batteries, the ratio of power input and power delivered by the charged batteries.

Making the power consumption data a mandatory requirement for standard battery chargers would result in robust market statistics for future discussions on market averages and achievable BATs. For power tools, this study presents achievable power consumptions (charging, maintenance, no-load) based on the identified BATs, but correlating them with the whole range of power tool products is not appropriate as the influencing parameters are even more complex than for “standard battery” chargers (huge range of cell capacities, output power of the charger spanning a wide range). Also for power tool chargers, a declaration of the power consumption according to a standardised procedure is recommended as key measure to make clear the differences in the market.

A major loophole regarding BC analysis is a lack of test standards. ENERGY STAR has developed a methodology for the purpose of the labelling program (see sub-task 1.3.3), but this neglects important losses. Furthermore, this methodology does not seem to be commonly used among manufacturers. Without a common test standard, the comparison of battery chargers or charging systems is very difficult due to the number of parameters affecting the final efficiency (e.g. battery chemistry). A development of a standard that takes into account all the relevant losses of a battery charger and that is accepted by industry seems of uttermost importance. It would seem important to follow related developments in California (also identified in sub-task 1.3.3).

A qualitative measure, which would be feasible to implement in the short term, is a special marking for microprocessor controlled BCs aimed at consumers, indicating that such chargers achieve important "battery saving".

8.2.2 ADDITIONAL RECOMMENDED MEASURES

8.2.2.1 ECO-PROFILE

An eco-profile (could be called as well eco declaration) for external power supplies due to the priorities and potential for further differentiation in the market could include at least average energy efficiency and no-load at 230VAC / 50Hz (plus marking in compliance with the internationally proposed marking protocol) for external power supplies and efficiency or losses for full load of halogen lighting transformers. For BC, the average losses in the different modes can make it into the eco-profile, but that requires a standardised test procedure (ENERGY STAR is not considered appropriate as, first, the most important mode, the charging mode, is not addressed, and second, the ENERGY STAR test cycle does not reflect the typical use profile as identified in the base case calculations).

At the Bill of Material (BOM) level there are some relevant design aspects which can be considered for an eco-profile: overall size is an issue as this is an indication for resource consumption for housing and the electronic circuitry. Basically the key indicator is the printed wired board (PWB) area. However, there are different PWB substrates in use, such as phenolic based FR1 materials and epoxy / glassfiber reinforced FR4 material with different environmental impacts “per area”. To work further on the BOM level with dedicated component classes (similar to umbrella specifications, which are in use for material declarations) is feasible, in principle. However, this may require a thorough review of the basic environmental data for these component classes. The EcoReport default dataset is suitable for a market assessment as required for this study, but to differentiate individual products the foreseen material / component categories for electronics specifically are not appropriate (e.g. allocation problems, summary of component classes which are partly definitely not contained in an EPS, FR4 as only PWB material).

Furthermore, standardisation aspects as outlined below can become part of an eco-profile. Eco-profile could also be extended to cover information on compliance with relevant EU directives, such as RoHS.

8.2.2.2 STANDARDISATION

Standardisation of interfaces (at least) as pointed out in task 6 is a recommended option to enhance lifetime of EPS and to allow for their more efficient use. It should be up to the standardisation process to take into account the technical obstacles which are linked to such a standardisation. Standardised interfaces may also help to multiply the use of innovative EPS in the future.

It could be an option, not to make use of standardised interfaces obligatory, but to give an incentive for EPS, which follow this standard (e.g. marking, mandatory consumer information, such as "this EPS comes / comes not with a standardised interface and can be used for other end-devices with the following requirements: … V, … A, …").

In principle, the standardisation of interfaces issue is not relevant only to "battery charger" that are subject to the current COPOLCO[1] work item proposal, but rather for all EPS/chargers.

8.2.2.3 CONSUMER INFORMATION

Information for the consumer could comprise

- Clear advice to avoid no-load losses
- Indication of worst-case no-load electricity costs
- Eco-profile data

8.3. IMPACT ANALYSIS

Requiring a redesign always has an impact on the industry:

- Innovative manufacturers following concepts to increase efficiency of power supplies and chargers for years already will have a clear market benefit from related efficiency thresholds.

- In some sectors, where the number of units produced is usually small, such as for medical equipment, a product redesign results in relatively higher non-recurring engineering costs, which might be a severe economic problem for some manufacturers.

- In highly competitive market environments (such as mobile phone market) the EPS manufacturer most likely will not be able to pass down production cost increases to their customers, affecting their margin.

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1 COPOLCO 42/2006: An International Standard for Harmonization for Interfaces for Battery Chargers and Consumer Goods powered by Rechargeable Batteries, October 2006. COPOLCO is the Committee on Consumer Policy of the International Organization for Standardization (ISO).

In case a requirement leads indirectly to a ban of certain basic technologies (such as linear EPS, magnetic transformers), this has a major market impact on manufacturers, which are specialised on these products. Although they usually also have got the alternative technologies in their product portfolio, important part of the turnover might be lost.

In general, market leaders for external power supplies are largely located in East Asia. European industry as such will be much less affected by such policy measures.

For the consumer – taking the LLCC as benchmark – any such requirements will lead to cost savings. Assuming 10 – 20 external power supplies per household the effect might sum up to individual savings (LCC) of several Euros per year.

8.4. SENSITIVITY ANALYSIS

The robustness of the outcomes of the study depends on the underlying assumptions. These assumptions are already mentioned at the single steps of the study. These are the most critical aspects and assumptions once again:

- Market data from different sources is not fully consistent, which required some principle estimations.
- Use patterns of external power supplies – especially when it comes to no-load times - are largely unknown and are rather subject to educated guesses.
- The base cases are as required by the methodology a “conscious abstraction of reality” but can not claim to be in a scientific statistical sense representative. The base cases reflect a selected number of major fields of application (taking also the use patterns for these fields of application into account mainly). For other applications, these base case calculations would look different, but in general the market is largely covered. The chosen number of base cases exceeds the basic requirements of the methodology and contributed to the overall robustness of the results for individual segments.
- Efficiency, no-load and BOM data when provided by manufacturers has not been verified in detail, but inconsistencies have been clarified with the data providers.
- For some product groups the database on e.g. efficiency is weak and needs improvement (mainly AC-AC EPS and to a certain extent BC). For EPS the data is based on various sources plus a review process.
- 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 differentiation of transformer core materials, no entries / analyses of hazardous materials foreseen such as flame retardants). Some basic data, e.g. for batteries, is

completely missing. The correctness of the EcoReport data has not been reviewed in detail by the consultants, but in some cases datasets seem to be subject to major uncertainties (examples: PWB raw material and assembly addressed, but not the PWB processing steps as such, which are usually a major contributor to the environmental impacts of PWBs; for ICs silicon area and mask layers usually is a common indicator, not the weight, which leads to major uncertainties)

- 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. Task 7 therefore talks about technical improvements options rather from the perspective of what is achievable with a blend of individual measures.

Due to these weaknesses the consultants have drawn conclusions only where the basis has been robust enough. The input from a huge number of industry experts allowed for a double check of critical data. To the best of our knowledge, the tendencies and general results of the study can be taken as valid.

8.4.1 Main Parameters

Uncertainties related to input data can have a direct influence on the results. For the purpose of sensitivity analysis, following three parameters are studied.

- Product price
- Electricity price
- Product life

While the first two parameters will show the variation of total consumer expenditure whereas the last parameters will show the variation of aggregated lot 7 impacts.

8.4.1.1 Product Price

The product price is varied by 5, 10, and 20% and the aggregated total consumer expenditure for the lot 7 is observed. As can be seen from the following table, the % consumer expenditure increase is about half of the % of product price increase.

Data	**Unit**	**Aggregated lot 7 for 2005**			
		base	**+5%**	**+10%**	**+20%**
Consumer Expenditure					
Total consumer expenditure	M Euros	6254	6424	6595	6936
% with respect to base-case			2.71	5.45	10.9

8.4.1.2 ELECTRICITY PRICE

The influence of electricity price on the total consumer expenditure is presented in the following table. The expenditure variation is observed with an increase of electricity by 10% and 20%. Further, calculations are also made for two special cases if the whole Europe pays the prevailing lowest and highest electricity prices in Europe (Estonia and Denmark respectively). The expenditure certainly will increase with the increasing electricity prices though not by the same proportions. Here the impact is even less than half, i.e. lower than the impact of product price.

Data	**Aggregated lot 7 for 2005**				
	Base	**10%**	**+20%**	**EU-min**	**EU-max**
Consumer Expenditure (M Euros)					
Total consumer expenditure	6254	6514	6774	5016	7516
% with respect to base-case		4.15	8.31	-20%	+20%

8.4.1.3 PRODUCT LIFE

A change in product life will have a direct influence on the stock as the product life was used to calculate the stock. The product life is reduced by 10% and 20% to see the variation of stock and the associated environmental impacts for the lot 7.

Data	**Unit**	**Aggregated lot 7 for 2005**		
		base	**-10%**	**-20%**
Total Energy (GER)	PJ	254	237 (-7.17%)	216 (-17.6%)
Electricity	TWh	19	18 (-5.56%)	16 (-18.75%)
Consumer Expenditure				
Total consumer expenditure	M Euros	6254	6010 (-4.05%)	5721 (-9.31%)

Reducing the product life has a significant effect on the energy consumption in the use-phase and also on the reduction in the total consumer expenditure. Though it may appear surprising, this is linked to the fact that the product life was used to calculate the stocks from 2005 sales and a reduced lifetime means smaller stock and thus reduced impacts. In real-life situation such variations may be less pronounced.

ANNEXES

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LOT 7 WEBSITE STATISTICS

Following figures show statistics related to the website visits for the Lot 7 preparatory study (http://www.ecocharger.org/).

Ecocharger.org - Number of visitors

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2006	0	0	0	0	0
Feb 2006	0	0	0	0	0
Mar 2006	0	0	0	0	0
Apr 2006	0	0	0	0	0
May 2006	16	18	115	202	1.29 MB
Jun 2006	115	200	962	2052	33.32 MB
Jul 2006	96	177	893	1963	28.71 MB
Aug 2006	181	304	1221	2694	51.74 MB
Sep 2006	271	536	1895	4122	143.48 MB
Oct 2006	210	365	1540	2908	105.84 MB
Nov 2006	326	554	2350	4566	219.60 MB
Dec 2006	402	722	2630	5158	468.83 MB
Total	1617	2876	11606	23665	1.03 GB

It can be observed that a this study generated a great deal of interest and a large number of visits were received throughout the study. Many stakeholders registered through the website and also asked questions on the lot 7 in specific and the EuP process in general. With the advancement of the study, more and more interest was shown by the stakeholders and this helped us to improve our analysis through an active participation by the stakeholders.

The website also served as an effective platform for dissemination of the information (different task reports) which allowed us their quick distribution and to a large set of audiences.

However, the website was only one channel of stakeholder contact which was further supplemented by bilateral meetings, telephonic conferences and regular meetings.

Ecocharger.org - Visitors per country (top 25)

Countries		Pages	Hits	Bandwidth
United States	us	2786	5304	270.79 MB
Germany	de	1545	3038	164.39 MB
France	fr	887	2154	56.89 MB
Great Britain	gb	884	1574	61.62 MB
Japan	jp	809	1571	119.90 MB
European Union	eu	717	1519	60.15 MB
Sweden	se	560	1068	33.86 MB
South Korea	kr	438	1167	25.00 MB
Finland	fi	434	1035	46.84 MB
Taiwan	tw	429	867	45.15 MB
Belgium	be	389	852	21.69 MB
Netherlands	nl	192	353	18.88 MB
Austria	at	184	325	15.48 MB
Luxembourg	lu	167	323	4.94 MB
Denmark	dk	159	407	8.99 MB
Switzerland	ch	137	243	21.94 MB
Australia	au	131	257	19.36 MB
Italy	it	117	255	6.27 MB
China	cn	110	192	11.01 MB
Spain	es	104	224	8.72 MB
Hong Kong	hk	102	193	4.63 MB
Portugal	pt	74	133	9.15 MB
Czech Republic	cz	41	183	1.72 MB
Unknown	ip	39	43	558.38 KB
Malaysia	my	34	97	707.98 KB
Others		137	288	14.23 MB

As shown in the figure above, the visitors to the lot 7 website came from different countries from all over the world. Many countries even from outside Europe (Asia and USA) showed a keen interest in this study. The interest from Asia can be attributed to the presence of most of the EPS/BC manufacturers in these countries and the presence of many American OEM manufacturers in consumer electronic sector explains their interest in the EuP process.

STAKEHOLDER CONSULTATION

Public events, where the study Consortium informed in general about the ongoing preparatory studies, the Lot 7 in particular, and encouraged stakeholders to get actively involved:

- 8-11 May 2006, IEEE International Symposium on Electronics & the Environment, San Francisco (USA)
- 1 June 2006, SMT Hybrid Packaging, Trade Fair and Congress, Nürnberg (Germany)
- 5-6 June 2006, 4th Science & Technology Conference Ecology in Electronics, Warsaw (Poland)
- 4-8 September 2006, Seminar "Emerging Environmental Requirements for Electrical & Electronic Products - Strategies and Technical Solutions for Compliance and Business Benefits" (funded by the EU AsiaProEco II Programme), Penang (Malaysia)
- 20 September 2006, American Electronics Association, Brussels (Belgium)
- 21-23 September 2006, 14. FED-Konferenz, Kassel (Germany)
- 12 October 2006, Seminar "Greening IT – Beyond Recycling", Final presentation of the EU funded project HEATSUN, Dublin (Ireland)
- 23 October 2006, 6. Deutsch-Japanische PIUS-Konferenz, Düsseldorf (Germany)
- 6-7 November 2006, The APEC Forum on Eco-design In the Supply Chain and EU Developments, Taipei (Taiwan)
- 13-16 November 2006, Going Green CARE INNOVATION 2006, Vienna (Austria)

Launch of the studies has been announced at http://www.ecodesignarc.info/, the website of the DG ENTR financed 2005 EcoDesign Awareness Raising Campaign for SMEs.

In addition, many bilateral industry contact meetings and teleconferences were organised.

REGISTERED STAKEHOLDERS

Below a list of Lot 7 registered stakeholders (companies, associations, institutes, etc.) is provided. Please note that all of them did not participate actively in the study, but they were regularly informed about the study and encouraged to contribute, comment and provide feedback.

EuP INDUSTRY (COMPANIES)

3Com
ABB
AcBel Polytech Inc.
Ansmann Energy GmbH
Apple
Astec Power (Emerson)
Biamp Systems
Black and Decker
BOSCH GmbH
BSH Bosch und Siemens Hausgeräte GmbH
BSkyB
Canon Inc.
Celetronix
Character Group
Cisco Systems
Commergy Ltd
Convergie
Dell
Delta
DIN Verbraucherrat
Emerson Energy Systems
EPSON Europe
Fabrimex AG
Flextronics
FRIWO Mobile Power GmbH/CEAG
FSP Group
Fujitsu Siemens Computers
Garmin International, Inc.
Gresham Power
Groupe SEB
Hama
Harman consumer
Hewlett-Packard
Hipro Electronics Co., Ltd.
Hitachi Koki

HiTek Power
IBM Deutschland GmbH
Infineon Technologies AG
Integrated Service Technology Co.
KEW Konzeptentwicklung GmbH / Loewe Opta GmbH
Kuantech (Shenzhen) Co., Ltd.
Lexmark International SAS
LG Electronics
Mascot
MGE
Microsoft
Miele & Cie. KG
Motorola Ltd
Nokia
ON Semiconductor
Panasonic
Panasonic Batteries
PanPower AB
Phihong UES Corporation
Philips Consumer Electronics
Phoenixtec Power CO
Pioneer Europe NV
Plantronics Ltd
Polycom
Power Integrations
Resource Smart
Ricoh Company Ltd.
ROAL Electronics SpA
Saft Batteries
Sagem
Salcomp
Samsung Electronics
Sanken Power Systems
Sanyo component
Siemens Home & Office Communication Devices GmbH & Co. KG
Sony Deutschland GmbH
Spectrum Brands, Inc.
ST
Standard Engineering, Lenovo Japan
Sun Microsystems, Inc
TCL Thomson Electronics Europe SAS
Texas Instruments
Toshiba Europe GmbH
Toshiba TEC Germany Imaging System GmbH

TridonicAtco
Uniross Group
Varta Consumer Batteries GmbH & Co. (Spectrum Brands)
VELUX A/S
Voller Energy

EuP INDUSTRY ASSOCIATIONS

AeA Europe
AHAM
AMDEA (Association of Manufacturers of Domestic Appliances)
BITKOM
British Toy & Hobby Association
CECED (European Committee of Domestic Equipment Manufacturers)
EECA (European Electronic Component Manufacturers Association)
EHI (Association of European Heating Industry)
EICTA
ELCFED (European Lamp Companies Federation)
EPBA (European Portable Battery Association)
EPTA (European Power Tool Association)
FIEEC
GDA
International Safety Equipment Association
JBCE
KEA
ORGALIME
RECHARGE
SECARTYS
SIMAVELEC
SIMTEC
SWICO
Technology Industries of Finland
ZVEI e.V.

MATERIAL PRODUCERS AND ASSOCIATIONS

AU Optronics
British Metals Recycling Association
EBV Elektronik BmbH & Co. KG
Eurofer
Eurometaux (European Association of Metals)
European Aluminium Association
IISI
ITRI
Plastics Europe

Tech-power International Co./Ltd.

OTHER BUSINESS ASSOCIATIONS

smallbusiness|europe
UEAPME (European Association of Craft, Small and Medium-sized Enterprises)
UNICE

ENVIRONMENTAL NGOs

BSI
EEB (European Environmental Bureau)
Energy Saving Trust
Environment and Development Foundation
Federation of Environmental Citizens Organisations
WWF European Policy Office

CONSUMER NGOs

ANEC
BEUC (Bureau Européen des Unions de Consommateurs)
COFACE (Confédération des Organisations familiales de la Communauté Européenne)
Consumer Council of DIN
Euro Coop (European Community of Consumer Cooperatives)

CONSULTANTS / INSTITUTES

BABT
ERA Technology Ltd
EuP Network Germany c/o Ökopol GmbH
eutema Technology Management GmbH
Foresite Systems
Foundation of Taiwan industry service (Integrated Service Technology Inc.)
Industrial Technology Research Institute
KERP
KREAB
Ökopol GmbH
PlesTech Ltd
Pollet Environmental Consulting
Punchline Energy
Skynet
TWI Ltd
WSP Environmental

MEMBER STATES REPRESENTATIVES

Danish Energy Authority

Ministry of Economy, Labour and Entrepreneurship of Croatia
Ministry of Economy of the Slovak Republic
SenterNovem
UK Department of Environment Market Transformation Programme
Umweltbundesamt

NATIONAL AND INTERNATIONAL AGENCIES

International Energy Agency
EEA
OECD Environmental Directorate
TUV Rheinland Hong Kong Ltd.
TUV Rheinland Taiwan
US Department of Commerce

STAKEHOLDER COMMENTS TO TASK REPORTS

Note: The task and sub-section numbers in italics refer to task report drafts published before November 2006.

Task	Sub-section	Comment	Action
1	*1.1*	Second paragraph: "are often delivered as an accessory with another main product" I would not say 'accessory with another main product' but 'part of a product', because the EPS or BC is not another product. The product is the complete product, e.g. inkjet printer, including the EPS. So, it is also not true that the end user does not have a choice regarding the energy efficiency of the product, e.g. the monitor. The end user does not have a choice regarding the parts of the product, amongst which is the EPS, but this is true for (most) other parts also.	Accepted: Text changed into "EPS and BC are often delivered as a part of an end-appliance".
1	*2.1.1*	What is the reason to restrict the definition to single (output) voltage EPS? I could imagine that the multiple voltage EPS has only a small percentage of the market.	True, the market share of such EPS is very limited and that is the reason most of the international EPS efficiency initiatives (Energy Star, California, MEPS, etc.) have focused on single voltage ones.
1	*2.1.1*	Page 9: distinction between EPS and BC: Can the distinction that is used by Energy Star also be used for an EU implementing measure? My suggestion would be that anything that is not explicitly a BC, i.e. has the battery or batteries (and nothing else) connected to the output, is an EPS. See also section 4.4.2.	It's true that there is no precise division between EPS/BC as such, BC is a kind of EPS with an additional function of charging the batteries and that's how we have considered them in this study.
1	*2.2.2*	What is meant with 'Internal power supplies in the *product application*'?	Accepted. Footnote added: "For example, power supplies integrated for a desktop computer which might be sold as a separate component but intended to be a part of the main product"
1	*3.1 & 3.4*	Why differentiate on technology (and not on functionality)? What relation does the summary of parameters in figure 3 have with the relevant environmental aspects? An example would be that PFC circuitry that is mandatory above 75 W input would increase no load power consumption and decrease efficiency. This section does not give a solution to the "horizontal problem", i.e. how to choose your product cases (which are only a few) so that they represent all EPS and BC, or at least that an implementing measure can be based on the analysis?	The performance of EPS/BC is closely related to the technology used and this a straightforward approach used to classify them in addition to the out power. For losses, many other aspects related to their use comes into picture. We have tried to cover a large range of products in different power range, however the choice of products was also influenced by the willingness of the industry to participate and provide the required data. Furthermore, implementing measures though can be based on this analysis, they don't fall precisely in the scope of this study.

1	1.1.3/1.1.4	Figure 1-3 does not reflect the text above the figure. The text indicates that output range is the first parameter and then the product classification can be done on the basis of end-applications. Another distinction is the differentiation between EPS and BC. This means that basic technology and power factor correction are not primary parameters for classification (however, basic technology – linear vs. switch-mode – might be relevant when assessing impact on industry).	No action. Basic technology and PFC are important parameters regarding the classification of EPS/BC, although they may not be primary parameters.
1	1.2.1.1	the test method of EN62301 can be used for any low power mode (see also Scope of the standard).	What is understood by "standby" in the context of this standards is defined under the Scope of the standard. No action.
1	*4.1.3.1*	EMC: Does this standard influence the efficiency levels of specific products? All current products on the market comply with EMC standards, so if you look at data of products on the market, this will give information on the efficiency (when complying with the standards).	The standard sets general requirements to EuPs that need to be respect by any new (eco-)design. So the standard deserves to be mentioned. No action.
1	*4.4.2*	Box 3: I suggest to move this box to an appendix.	Box retained in the document, as it is the only existing test method for battery chargers (battery charging systems). No action.
1	1.2.4	Boxes 1-2 and 1-3 do not improve the readibility of this section. Why not move to an appendix?	Boxes retained in the document, as they are considered important items and not excessively bulky.
1	1.3	Existing legislation and voluntary agreements	Title of the chapter is defined by the MEEuP methodology. No action.
1	*4.5*	Page 40: I do not understand your remark in the second paragraph ("The opportunity to create one standard for all the EPS ... are different"), because in the next paragraph you indicate that many existing measures have adopted the same methods. Or do you mean one standard for both EPS and chargers?	Accepted: Text modified.
1	1.3.1.2 & 1.3.3.3	general remark: For evaluation of existing voluntary agreements, it is important to provide an estimate of the market coverage of the agreement. Otherwise nothing can be concluded regarding whether the voluntary agreement can forestall an implementing measure. For some schemes you mention e.g. for the Eco-label for portable computers "there were no labelled products in this category". Is it possible to add data on the market coverage for the other agreements, especially the Code of Conduct? For the Code of Conduct you mention the percentage of models that comply, but that does not provide any information on market coverage (because you do not mention any information on the total market). My personal estimate is that the market coverage of the Code of Conduct in general is below 50 %, because coverage is good for EPS for mobile phones and laptops, but bad or non existent for EPS for other products.	Unfortunately, no data was available to make such estimations.
1		I didn't find in it any mention of 2 standards that seem to me relevant for this product category:	Accepted. These standards added.

		- IEC 62018: Power consumption of information technology equipment - Measurement methods - IEC 62087: Power consumption of information technology equipment - Measurement methods	
1		Page 10: Different types of EPS/BC and their function. "Pure BC" --> BC for individual cells; "EPS/BC with dual function" --> EPS/BC for incorporated batteries; " The battery charging system for a power tool" --> must be separate as a charger and an EPS and the charger must be call "BC for battery pack" and placed just after the BC for individual cells	Partly accepted: Naming modified.
1		Page 17: Wattage --> power	Accepted: modified
1		Page 24: The chapter starting by " For a sealed lead-acid battery ...in about one hour" is not necessary and not at the right place. (as it concern all the different type of batteries)	Accepted: The paragraph partly deleted, partly merged with other appropriate paragraphs
1		Information on additional EuP regulations are available at the Green Pages of our company's website	Document supplemented with new information e.g. on Canadian standards development and Energy Star proposed Tier 2 requirements
1	*2.1.1*	It may be useful here to cite the Australian Test Standard (AS/NZS 4665.1) which is the only current national standard relating directly to the energy performance of EPS. I understand that Standards Australia proposed this standard as a new work item to the IEC, but I'm unsure of the current status of this. This could be clarified by contacting the Australian Greenhouse Office.	Australian Greenhouse Office was contacted by e-mail, but no further information was obtained.
1	*5.4.2.3*	Chinese mandatory program: The MEPS for external power supplies in China has been agreed by SAC, and has been submitted to the WTO/ process. I understand that it will be approved by SAC towards the end of 2006. For further information contact CNIS.	Updated information added to the document.
1	*3.2.1*	Linear power supplies are less susceptible to damage caused by variations in input voltage and therefore are preferred in some countries with unstable mains power, and where access for replacement is difficult.	This is pointed out in sub-section 3.3 (local infrastructure).
2	2.2.2	The stock figures in table 2-1 are only valid with the following assumptions: • constant sales (2005 figures) during the lifetime • zero stock at the beginning Do you know whether these assumptions are (approximately) true?	As already written in section 2.2.2 "This is likely to slightly overestimate the current stock as the EPS/BC sales have been annually growing in the past years." Nevertheless, based on the comparison with published estimates "It can be concluded that the estimated stock does not deviate significantly from the similar estimates in MS level or in other countries of roughly comparable socio-economic conditions."
2	2.3.2.4	End-application driven trends: Page 16: Regarding the iPod example: powering through an EPS is still possible (even if the iPod as such is no longer sold with EPS).	Maybe true in theory, but consumers seldom buy a separate EPS if it's not provided with the iPod or other similar appliance. No

		Page 17: Are EPS with (manual) voltage switch still sold?	action.
2	2.3.2.7	Shift from Linear to Switched-mode power supplies: In task 1 (section 1.1.3.1) you described the linear and switched-mode technologies and ended each description with positive and negative points of each technology. How do the negative aspects of the switched-mode technology be reviewed in the light of this (2.3.2.7) section? Are the negative aspects, especially the interference (which you indicate is higher for switched-mode), so far reduced that they do not play a role any longer? Or a the negative aspects only valid for certain end use applications?	The sensitiveness of SMPS vis-à-vis instabilities of the power grid are discusses in section 3.3.
2	2.4.1	What is the factor 3 based upon? It seems high to me, because most costs involved in this mark-up are marginal costs, i.e. it is not dealing with the EPS/BC separately but with the EPS/BC together with the end-application. But as you indicate, the factor serves as general indication only.	The factor is based on few of expert opinions, which pointed to the same factor. And as the comment points out, the factor provides an approximation. The final stakeholder meeting agreed on this factor and no alternative has been proposed.
2		General: I miss a summary in this document, and especially a summary of data or parameters that are relevant for the rest of the study.	Accepted: Task 2 re-drafted and supplemented with additional market data
2		General: In my opinion, although obvious, one of the conclusions is that the product EPS and the product BC each have a much large yearly (sales) volume than the 200.000 units mentioned in the Directive.	Accepted: This conclusion mentioned explicitly.
2		General: be a little bit more specific, e.g. saying explicitly that switched-mode power supplies are expected to have a market share of more than 80 % in 2010.	Accepted: Such information is provided in the sub-section 2.3.2.7 under Market Trends.
2		Page 15: During discussions on the EU Code of Conduct much lower break-even-points have been mentioned (between 2 and 10 W, if I remember well). On page 6 you state that the top-ten of UK mobile phones are served by four (generic) types of power supplies, all of them switching supplies. Since the power range of these power supplies is under 10 W, they would be far away from you break-even-point. Are these mobile phone manufacturers making uneconomical decisions? I assume that these manufacturers take into account other factors (which you also acknowledge in the sentence after the sentence cited above) and these can be (far) more important than only the cost of material equation.	Accepted: Text modified into "Currently, this break-even-point is somewhere in the range of 15–20 W for most of the applications. For some applications such as mobile phones, this break even point can be even lower (3-4 W) because of mass scale production."
2		Page 28 (Conclusions, base case definition): Does the analysis in Task 2 provide other insights regarding the scope and the product categorization as presented in Task 1 (section 3.4 Conclusions)? E.g. is the categorization in 3 output ranges (and the boundaries) still useful?	yes
2		Page 28 (Conclusions, policy analysis): The policy analysis has to consider current voluntary agreements etc. Yes, but as I indicated in my comments on Task 1 it is important to provide an estimate of the market coverage of the agreement, because without it will be difficult/useless to analyse the agreement in Task 7. I would have thought that Task 2 would provide this estimate; is this possible? Of course this is less	Unfortunately, no data was available to make such estimations. No action.

		relevant for (mandatory) legislation.	
2		Market data: Not always up to data; To less focus on global market; To less segmentation between external/internal but modular/internal onboard; Sources limited	Accepted: Task 2 re-drafted and supplemented with additional market data
2		Costing: Based on identical output power, single range input, CV output. Breakeven switch-mode/linear today is definitely in the sub 3W range.	Partially accepted: Text modified into "Currently, this break-even-point is somewhere in the range of 15–20 W for most of the applications. For some applications such as mobile phones, this break even point can be even lower (3-4 W) because of mass scale production." Additionally, Task 2 supplemented with additional data.
2		Battery Chargers (charging boxes / plug in for standard consumer round cells) should be separated from EPS, because they entirely just charge standard round cells. Therefore they are an appliance not an accessory. Tool chargers = battery chargers. Cell phone chargers = EPS with charging functionality.	Fully agree. The consistency of terminology has been improved in the whole document (all tasks)
2		Page 7: Reference 11 “ Recharge 2006 (calculated from ITT-Takeshita on the basis of EU market represents 20 % of the worldwide market)	This table was not retained in the final draft. No action.
2		“There is a strong evolution in the battery market, driven mainly by the development of end-applications.” The application of the different battery types has an effect on the needed charging technology and this has a direct influence on the batter chargers: •Lead-acid batteries serve a stable market segment of larger power applications where weight is of little concern. They suffer of their low energy density compared to other technologies which makes them as the less attractive for the mobile computing and communication applications. •NiCd batteries, are slowly loosing market share in the portable household equipment market segment but gaining market share in the high power range applications. limited cycle life and inconvenience caused by the so-called memory effect. In particular, the lower energy density of NiCd batteries compared to other technologies makes NiCd less attractive for the mobile computing and communication devices. However, currently NiCd is the predominant technology in the cordless phone.	Accepted: Text modified accordingly.
2	*5*	Although stated elsewhere it may be useful to identify portability at a key market trend driving the increase in switch mode power supplies.	Accepted. Text added to section 2.3.2.4: "Mobile society and portable end-appliances demand small EPS/BC, which is driving the market towards more efficient switched-mode technology."
2	*5.3*	It may be useful here to note the Australian MEPS requirements contained in AS/NZS 4665.1 and also that there are other states as well as California which have passed	Text added to section 2.3.2.3: "Mandatory standards in Australia/New Zealand and similar developments in a number of

		legislation requiring minimum performance standards for EPS. I have attached a table listing these, although it may require updating.	U.S. federal states are likely to enforce this trend."
2	*5.4*	In some countries the growth in low voltage lamps is extremely high and this may account for some of this growth in lighting products (i.e. not just ballasts excluded from this project).	Accepted. Text modified taking into account the comment.
2	*7*	While you are right in stating that USB-powering offers a technical alternative to EPS, there are limitations to this and it may be helpful to indicate here that this may not have much impact on the market.	Other references give rather an opposite view. No changes to the document.
2		An issue for further consideration, at least in the program design stage, is the treatment of EPS supplies for 'spare parts'. Although EPS do not require spare parts, shipments of replacement end-use equipment is supplied un warranty or similar arrangements for a number of years. Other programs have been lobbied for an allowance to supply such products, together with their original EPS, after the implementation of MEPS.	No action. This is a preparatory study. Program design state will come later.
2		Historically the copper price has fluctuated a lot with large difference between the peaks and bottoms. During 2006 we have seen a peak and the trend is now downwards. A Swedish mining company BOLIDEN is investing 5 billion SEK (maybe more) in their copper mine Aitik located in the northern parts of Sweden. Their investment is based upon their long term prognoses of the copper price to go down from the price level around 350 cent/pound to 100 cent/pound. I have read other articles with similar prognoses about the copper price which is expected to fall to around 30% or present price.	In the long term anything is possible, in the preparatory study we are primarily looking at the short/mid-term future. In addition, copper is only one of the raw materials and in general raw material prices as expected to stay on a high level rather than decrease. No action.
3	3.1.1	Page 6: "The power switch is normally placed on the primary side of the transformer". What do you mean with "normally": almost always (which I doubt) or in a majority (more than 50 %) of the cases? If the switch is placed on the secondary side then the no-load condition is important. Anyway: the modes regarding the halogen lighting should refer to the lighting and not to the transformer; this means that both off-mode (no light) and on-mode (light) are relevant. The design (place of the power switch, no-load consumption of the transformer) then determines whether there is any power consumption in the off-mode and how large this consumption is.	Issue was discussed in the final stakeholder meeting and as a result the text was somewhat modified.
3		General: The load profiles are very much based upon manufacturers data. If they have the best understanding of these issues, can they back up their figures with data from surveys? There is more data available: '2005 Intrusive Residential Standby Survey Report' for Australia and German study 'Technical and legal application possibilities of the obligatory labelling of the standby consumption of electrical household and office appliances'	Accepted: These documents have been consulted and relevant data is presented in the revised Task 3.

3		General: The study provides information on load profiles for a limited number of appliances. However, I assume that possible implementing measures will be targeted on all external power supplies.	The preparatory study is based on some examples and is an abstraction of reality. Implementing measures are not discussed here.
3	2.1	Page 3 (1st paragraph): The 'classic split incentive case' applies to all products consumers buy: also with a computer or a TV the manufacturer chooses the power supply (and other components that affect the power consumption), whereas the consumer pays the electricity bill. The difference with products with an external power supply is that the power supply seems a separate product, but in practice it is not. (However, one could image that when ordering a product you could also choose the efficiency of the (external) power supply).	Too general a comment. No action.
3	2.1	Page 3 (2nd paragraph): The exception of large household appliance is due to the EU energy label, but also because the energy consumption is significant. Secondly, interest in ecological criteria does not mean that consumers will take these criteria into account in a real buying situation.	Accepted. Text added: "It may be also argued that an interest in ecological criteria does not mean that consumers will take these criteria into account in the actual purchase situation."
3	2.1	Page 4 (last paragraph of section 2.1): It seems as if labelling of EPS/BC would be a solution to the problem of transforming the market towards more efficient appliances. I don't think this is the case, because – contrary to large household appliances – energy consumption of each EPS/BC is too small to trigger consumer action. Furthermore, consumers buy the total product and not the EPS/BC.	Accepted. Text rearranged and modified to take the comment into account.
3	2.2	Page 4 (first paragraph): I fully agree with your assumption that a switch on EPS/BC is not the solution, because it will not be used.	Accepted, but no changes.
3	2.3	First paragraph: It might be even worse, because in many cases targets are to decrease costs; so even a constant cost solution is not an option.	Accepted. Proposed text added.
3	2.4	Page 5 (2nd paragraph): Is harmonisation of connectors as well as output voltage and current an option within the Ecodesign directive?	Policy question. No action.
3	3.4.3	("While reducing the … universal EPS may compromise … will be less efficient for lower outputs"): this is not true if the EPS has a constant efficiency over the total output range (or at least from 10 % onwards). As far as I know EPSs exist with an (almost) flat efficiency curve between 10 % and 100 % load.	Flat efficiency curve does not seem common for the EPS.
3	2.5	Page 6: Apparently, these opportunities did not (yet) results in a shift towards more efficient EPS on the market?	Rhetoric question: no changes to the document
3		Page 10 (table 4): Would this table mean that when the cordless phone is charged, it still draws 50 % of the rated load?	The answer is yes. No action.
3		Page 10 (table 6): This is an example of an appliance that can be neglected in the calculations, but will of course still fall within the scope of an implementing measure.	Accepted. The table replaced by text.

3	3.1.3.1	Page 11(Universal Battery Chargers): 50 cycles per year is approximately 1 cycle per week (= 168 hours). How does the figure of 2.75 hours per day in no-load mode fit in this calculation? Using the percentage of table 3-3 (28 % in no-load (standby)), my result would be: 168 – 9 (charging) – 3.5 (maintenance) = 155, 5 hours per week = 22,2 hours per day in no-load maximum * 0,28 (percentage of households that leave the charger plugged in) = 6.22 hours.	The figure is based on an estimate given by a manufacturer. No action.
3	*3.3.1*	I miss the kitchen tools in section 3.3.1.	Accepted, but no action as no data was found/received on kitchen tools
3		Page 11(table 8): Off (but still connected, plugged in).	Accepted. Footnote added: "The printer is off, but the EPS is still likely to be plugged in and connected to the printer."
3		Page 12 (table 9): This would mean that the standby power consumption is at 25 % of the rated load. Is that correct?	Yes.
3		Page 12 (table 10): See Australian study for alternative figures.	No action. No appropriate alternative figures were found in the Australian study.
3	3.1.5	Best Practice in sustainable product use: Conclusion: these are not feasible options to follow, at least not for an implementing measure under the Ecodesign directive (Some manufacturers however might already include these advices in their user manual). However, some of the options would make sense if they can be realised in the hardware, e.g. switching the BC off as soon as the batteries are fully charged. Note that unplugging the EPS of e.g. a laptop is probably not an appreciated advice because this in general means that power management will kick in, which will affect screen luminance, processor speed etc.	The feasibility of technical improvement options are analysed in section 7, here the aim is to indicate best practise regarding user behaviour. The unplugging of a laptop does not in itself lead to changes in e.g. screen luminance. This depends on the power saving settings which can be modified. No action.
3	*4*	Page 14 (conclusions): But even if the information would be available, the effect on consumer demand would be small (see also remark above on last paragraph of section 2.1).	Accepted. Text added: "On the other hand, even if the information would be available, its effect on the consumer demand is expected to be small"
3		Despite the fact that power consumption is an international issue, I am not amused that you are chiefly referring to US-sources! The behaviour of US people and of Europeans is entirely different. So, please work with European sources/references/material only - and don't show us a picture (Figure 1) with EPS that are sold in a different "galaxy!	European sources are preferred and used where available. No action.
3		Laptops: more and more Europeans understand that the lifetime = the number of recharging cycles and in particular the capacity of the batteries is significantly reduced when the battery is always in. So, conscious people remove the battery when they work in the office and only use it when they forgot the ac supply/charger and/or when there is no ac socket around. I suggest to ask the leading laptop makers - they will be happy to confirm this.	The laptop load profiles and the plugged-in time are based on data from leading laptop manufacturers. No action.

3		Other than laptop supplies that also consume energy when the battery is fully charged, changers for mobile phones have such a tiny power consumption both in idle mode and when they are not (immediately) disconnected from the fully charged phone that you have to add that consumption of thousands of chargers in order to obtain a value in the order of 1 kWh! So, please don't consider peanuts!	The contribution of mobile phone EPS was analysed in the later steps of the study. No action.
3		"Harmonisation of connectors as well as of output voltage and current." a) many years ago, someone made an approach to the EU COM to standardise all chargers so that only one universal charger would be left. b) it is not even possible to standardise a European bureaucrat -even though they often behave in the same way... c) the freedom to design the products is a basic right of every producer - it is the consumer to decide which brand/model he wants to buy! However, don't even dream of the possibility to a) "educate" the consumer b) "stimulate" him with an eco-tax system c) not being cheated by "clever" importers --> if EUP or whatever other directive would try and regulate = limit the power consumption on one hand and even make an attempt to introduce an "Eco-Tax", in practice, this would surely fail!	Rather an opinion/policy comment. No action.
3		The biggest problems in environmental legislation are... Conclusion: you have no other chance than to observe and appreciate what green companies are improving year by year, but please leave us alone with suggestions and laws that are not realistic.	A general policy comment. No action.
3	*2.1*	The document assets that there is no marking for energy efficiency on EPS or BC. This is rapidly changing as the efficiency mark of "III" or "IV" is required for California and Australia. By 1Q07, almost all EPS will be marked for efficiency so they can be sold into California. The same EPS, if universal voltage input, can also be sold to the EU market.	Accepted. Text supplemented with this information.
3	*2.2*	Education of consumers on annual energy consumption of household appliances should be a priority of public authorities before moving to energy efficiency issues.	Policy comment. No action.
3	*2.4*	The document recommends making connections more universal to extend the lifetime of an EPS. This is not satisfactory to either EPS manufacturers or integrators as this would increase the liability risks when the EPS is re-used outside of the manufacturers testing and intended use. All EPS do not contain the same output voltage. EPS's designs contain different output voltages and current levels to support different application and products. Encouraging the same connector would promote use or re-use of an adapter into an application that could render an unsafe power or thermal limit. This should be discouraged. Re-usability is not an issue for EPS of printers. Besides, universality would not optimize energy efficiency of EPS.	The document does not make recommendations. However, text has been modified and the following has been added: "manufacturers have expressed the concern that the harmonisation of the connectors could lead to the (re-)use of EPS/BC with applications that are outside of the manufacturers testing and intended use. This could lead to unsafe power or thermal limit conditions, increasing manufacturers' liability risks."

3	*3.3.2.1*	In this section the consortium provides many assumptions that are not backed up with data. Could you please be more specific?	Data source is mentioned when available. Assumptions were necessary is no data was available.
3	*4*	The conclusion is incorrect for EPS where the EPS is used on a product, which has an additional system power limit of Energy Star. To meet the California EPS requirements , which is a) no load and b) average efficiency. The EPS has to be designed efficiently across all loads. The EPS must be efficient or the "product" will not meet Energy Star in the Off mode and Sleep mode. The majority of the IJ printer time is covered by the Sleep and Off modes. In addition, the EPS remains connected to the printer unlike the cellular phone or portable equipment (drills, etc.). Therefore the "no-load" makes no sense for printer devices. However, the California EPS has a 0.75W no load limit for a mark "III" adapter and 0.5W for a mark "IV" adapter.	No action. The conclusions are for EPS/BC in general not for the products of one brand or Energy Star labelled products.
3	*2.1*	Note that the international labelling initiative is not a consumer label, but a mark to assist verification.	Accepted. Footnote added: "aimed at business-to-business and regulation enforcement rather than at consumers"
3	*2.2*	Note that some 'smart' EPS products are able to sense when no loads are attached and switch off – thereby reducing standby power to zero. This is very important!	No action. Regarding the current sales and stock of EPS/BC, this would be rather an improvement option.
3	*2.3*	Although stated elsewhere, it should bee mentioned that the reduced size and weight of switch-mode EPS can, in some circumstances, save transportation costs.	No action. This is indeed mentioned elsewhere in an appropriate section.
4	4.1.1	Mains cable not included in BOM: this is strange because the mains cable is an integral part of the EPS/BC. The argument that the cable is supplied as a separate part, i.e. not plugged in/attached to the case of the EPS/BC, is not unique for this product. If the EPS/BC is small/light, the main cable might be a significant part of the BOM. A solution would be to include a standard mains cable.	Mains cable is (or can be) an important part of the EPS, but as no improvement potential for cables has been identified (besides the trivial recommendation to use shorter cables), this is not relevant for the study. An additional sentence added to clarify the issue.
4	4.3.1.3	Power factor correction: do you have any indications from a technical analysis about the impact on efficiency and no-load? The statistical difference of 1 % mentioned in the report might also be due to the fact that manufacturers put some extra efforts to improve efficiency to stay below the PFC level (because of cost reasons: no PFC circuitry, testing costs etc.). Is the difference of 30 mW statistically significant? The technical aspects of PFC are treated in section 4.4.1 but no quantitative impacts are given.	Discussions with manufacturers lead to the conclusion that the PFC is resulting in lower efficiency and higher no-load losses in principle, but this effect cannot be quantified as there are no two otherwise equal EPS designs, one with and one without PFC, to come to a comparison, and as there are many more parameters that have an influence. A difference of 30mW is not statistically significant. No action.
4	4.3.1.6	What is the average of the data provided by the manufacturers; to provide an indication?	See data in section 4.3.2 for such information.

4	4.4	Use Phase: Although maybe theoretical correct, the placing of this section here is a little bit strange. A lot of items are also treated elsewhere in the report, especially in task 1: e.g. power factor correction and battery charging. What would be interesting to know and what the section does not answer is the question: what part of the design and components is the same for EPS/BC serving different applications. I get the impression that manufacturers standardize their designs to a large degree and then fine tune to serve different applications (in a certain power range).	The section is drafted and placed following the MEEuP methodology. Second part, in principle right, components are maybe the same but the actual design of different manufacturers/models are different.
4		A large part of the report discusses "specifications"; of course specifications are – especially for EPS and battery chargers – determined by the product system, the "environment" of the product under examination (the EPS, battery charger). You conclude (in paragraph 2.6) that the base case need to reflect all these parameters. This seems to me an almost impossible task, and – as you show in the task 5 report – is also not done by other parts of the world who want to regulate EPS. What the important question is, is what improvements can be made regarding energy efficiency, including no load consumption (and maybe on other environmental aspects) by EPS and battery chargers, assuming that they fulfil the relevant functional specifications? In other words: what specifications make more efficient power supplies difficult? You mention one example of the output voltage: EPS with low output voltage tend to be less efficient than EPS with higher output voltages. Have you discovered other specifications?	No action. Comment refers to interim conclusions that are not taken aboard in the final draft.
4		Another aspect are the different use modes of the different end-applications. This is also a central argument in the TIAX report. The different use modes and the time the products spend in these modes are not relevant for the technical assessment of improvement options, but only for the economical assessment. Since usage patterns vary to a large extent (especially regarding no load consumption), not only between end-applications but also for the same end-application, you need to work with averages. Furthermore, since an implementing measure need to be as general as possible (e.g. you don't want different measures for EPS for MP3 players and mobile phones), also averaging between end-uses will be necessary; unless detailed load profiles are available for every end-use. Last but not least: new end-uses will appear on the market for which at the moment no load profile is available, but the EPS or battery charger will be covered by the implementing measure.	No action. The load profiles and times are needed for the quantification of the environmental impacts as per MEEUP methodology. Improvement options will be assessed in the later stage.
4	*p. 3*	Stand-alone products: also dedicated battery chargers, where the battery is inserted in the charger instead of plugging the charger in the end equipment, might not be stand-alone products but are sold with the product in which the battery is used (example: Canon 350D camera).	Accepted. Text modified taking the comment into account.
4	*p.3*	Not only can EPS design not influence network or infrastructure aspects, also it is on	Statement is correct, but no action, as this is a side aspect of the

		front not known for which system the mobile phone will be used, or otherwise, the mobile phone must work with all networks.	"system" which is irrelevant for the EPS in the end.
4	*p.6*	What is a secateur? An electric kitchen knife?	"Secateur" was understood as a "grass cutter / trimmer", [but not lawn mower]; however, deleted from the figure.
4	*p.7*	footnote 4: the reference to page 10 is not correct, i.e. the text of the report does not treat the subject of output voltages and the consequences for energy efficiency (as far as I could detect).	Partly accepted. The report actually addresses the topic of voltage-efficiency correlation, but not on p. 10 but on pages 30-31. Footnote will be changed accordingly, statement as such is correct.
4	*p.14*	Device integration: Do you mention this as a solution? The products you mention (hard disk, modem) are mostly integrated, but there are cases where an external version is useful. You cannot expect that an implementing measure prescribes these products to be integrated and/or forbids the external version.	No action. Device integration is mentioned only as an example of an alternative at system level. Implementing measures are not drafted here.
4	*p.14*	USB powered devices: USB-powering might be less efficient than direct powering, but USB powering forces the product to run within the power limits of the USB port, so the power consumption might be less than when powered directly (with no power limit).	No action. The power limit (in watts) is not relevant for overall power consumption, because lower power limit might mean that the device has to be charged longer, which in the end might mean higher total power losses than at high charging power. No robust and representative data is available on this effect, but the general statement, that the power supply system of USB-powering (e.g. EPS of a laptop, laptop battery, power transformation and supply from battery to USB-port) is less efficient than direct powering (EPS "only") is definitely correct.
4	*2*	It is not true that EPS do not come (or are sold) as stand-alone products. Although the power requirements of end-use equipment largely dictate the specification and usage patterns of EPS, this is not true of standby power consumption by EPS (i.e. Plugged-in off).	Accepted. Text modified into "External power supplies and dedicated battery chargers (sold with/for an end-appliance) are not used as stand-alone products"
4	*2 (Fig. 2)*	I'm unsure what cost-effective' means in this context. Cost-effective to whom and under what circumstances?	Change / clarification: "cost effective *(production costs)*"
4	*2.2.1*	Note that not all halogen lamp transformers are dimmable.	Accepted / change: "Another specific *but optional* requirement for halogen lamps..."
4	4.6	These are not conclusions, but a summary.	Correct, it's rather a conclusive summary of task 4.
5		General comments: I assume that also categories of end-use appliances that are not covered by the base cases still will be covered by a implementing measure on EPS and BC. Can you after having done the detailed analysis for the various base cases still conclude that a detailed split-up is necessary?	Detailed analysis was considered necessary to cover the variety of products that fall under Lot 7.

6		General comment Page 5 (However, the efficiency or other performance levels claimed by them have not been verified independently): Have competing technologies/solutions been checked/commented by competitors?	No comments from competitors have been received to this date. Page 1 contains the note: "Most of the technical data for this task has been provided directly by the manufacturers/designers or come from other published information. However, the efficiency or other performance levels claimed by them have not been verified independently."
6	6.1.1	Page 2 (However, this does not mean that all kind of power requirement specifications can be met with such highly efficient EPS): Why not?	Power output in Watts is not the only important characteristic regarding the requirements of an end-appliance.
6	6.1.1	Page 7 (Table 6-1): There seems to be little correlation between output power and no load power consumption. E.g. the first model (output power 1.5 W) has a no load consumption of 0.181 W and the third last model (output power 148.8 W) has a no load consumption of 0.168 W. Compare this with the “premium” charger on page 11 with a no-load consumption of 2.1 W.	The 2.1 W example is a micro-controlled battery charger, which typically have somewhat higher no-load consumption because they contain a control circuit that protects the battery.
6	6.1.5	Page 11:Why has the feasible “BAT” a higher standby power consumption?	The BAT contains a control circuitry which protects the battery and limits the on-mode energy consumption of a charger; however, the control circuitry leads to somewhat higher stand-by consumption.
6	6.3	Page 23 (Toroidal Transformer): Why is this development relevant, especially if targeted at the lower power range? If you look at the no-load losses in table 6-7, these are (much) larger than many of the figures in table 6-1. Is this product mass produced? How do the advantages as claimed by the manufacturer compare with other solutions? E.g. is the size as small or smaller than the ultra-small power supplies presented in section 6.1.2?	New Toroidal Transformers are mentioned in task 6 as they are claimed to have significantly better energy performance than the similar products currently on the market. This option is compared to other technical improvement options in task 7.
6	6.5.3	Why are solar chargers considered BNAT? They are available on the market for already several years. What are (dis)advantages compared with other chargers?	In principle, this is correct. However, the solar chargers are rather alternative products than alternative technologies than can be used to modify existing products. Furthermore, solar chargers are still not considered as a main stream alternative to the existing EPS/BC.
7	7.1.14	Is this a viable option for an implementing measure? No, because I cannot think of any legal measure that can force consumers to unplug their power supplies when not in use, let alone how such a measure could be enforced. Is this a viable option for a voluntary agreement? No, because such an agreement never can give any certainty about the results. One of the reason why EPS are subject of an Ecodesign study is that the multitude of EPS in a home and the small savings per EPS make consumer behaviour not a suitable instrument for achieving energy savings.	User behaviour presents a large potential for energy savings, as illustrated by this "option". But, indeed, the impacts of any measures aimed at behaviour changes are hard to quantify and consequently this option is not taken into account in section 7.2.12 where LLCC and BAT are derived.

		Therefore, I suggest to exclude the consumer behaviour option from the analysis.	
7	7.1.15	Page 37 (bullets): is there any technical background to this, i.e. why there is only one compliant EPS with 12 V above 60 W output? Or are these products (voltage and power combination) simply not needed?	It is assumed, that there are just no high power EPS with low output voltage on the market (no need). At least there are no indications that low voltage EPS could not achieve high efficiencies (rather the opposite is true). No action.
7	7.1.15	Page 35-36: a no-load power consumption of 0.75 W or even 0.5 W seems far too high compared with what is already possible.	Indeed, lower no-loads are possible (see base cases for example!), but this first improvement step is about Energy Star, tier 1, criteria. Lower no-loads are taken into account in following options. No action.
7	7.1.15	Page 37 (costs): since Ecodesign measures can or have to target the least lifecycle cost (LCC) point and since a 5 % cost increase does not reach this LCC (see also page 13) there is room to decrease no-load power to e.g. 0.1 W for all base cases.	There is no robust data available on technical options to achieve 0.1 W WITHOUT having a contradictory effect on efficiency (as both have to be balanced thoroughly). No cost data available on dedicated 0.1 W products. However, the step down from 0.3 W to 0.1 W means only electricity cost savings of a few cents per year (depending on use patterns), which are likely to be offset by higher purchase prices. No action.
7	7.2.11	Page 58: On what is the conclusion that the microprocessor controlled charger is too costly based upon?	No action. Conclusion is based on market data.
Comments after the final stakeholder meeting			
1	I-4	Bottom picture description. I believe the word inverter is spelled wrong.	Accepted and text changed accordingly.
1	I-12	Last line of the first paragraph - I believe the word should be topology, not typology. Also misspelled in the footnote.	Accepted and text changed accordingly.
1	I-12	Second paragraph - the universal input voltage range is 85 V to 265 V, not 100 V to 240 V as stated.	Accepted and text changed accordingly.
1	I-22	EN 62087 title line - "video" is misspelled	Accepted and text changed accordingly.
1	I-34	First line at the top of the page - "battery" is misspelled	Accepted and text changed accordingly.
1	I-44	California EPS standards. The new effective date for phase 1 is January 1, 2007 for some products and July 1, 2007 for all other products. I'm not sure if the Phase 2 effective date has been pushed out. The CEC should be asked.	Accepted and text modified according to the latest amended CEC standards (December 2006)
1	I-45	I believe the second sentence in the first paragraph should start with the words "Table 1-8".	Accepted and text changed accordingly.
1	I-49	On page 32 of the April 16, 2006 Korea e-Standby program document, they have now added the ENERGY STAR active mode minimum efficiency specs. You may want to add this to the section on Korea EPS standards.	Accepted and information added as a stakeholder comment.

1		MEPS are not yet mandatory in Australia. I am working on what is called a Regulatory Impact Statement, which is part of the Australian process to analyse the costs, benefits and other impacts of proposed regulation and alternatives.	Text modified according to the latest information from www.energyrating.gov.au
2		For DIY cordless power tools & chargers 7 year life is realistic. But for professional market this is too long: 2 years is proposed.	Accepted. The lifetime of professional tool chargers is changed to 2 years and the relevant parts of the document changed accordingly.
4	IV-44 to IV-47	The letter U is used for the voltage curve line on the graphs. Shouldn't that be the letter V instead?	No. U is the symbol for "voltage", V is the unit itself (volts).
6	VI-4	Please change the word Manufacturer to Designer for the Power Integrations EPS example. We design EPS that use our ICs. We do not manufacture power supplies for sale.	Accepted and text changed accordingly.
6	VI-11	I'd appreciate it if you would consider rewording this a little so that it's clear that EcoSmart technology is a feature that is part of our IC product line, not a product family name. If you could change the second paragraph to read - Currently, four Power Integrations off-line power conversion IC product families incorporate EcoSmart technology, covering a power output range from 0 W to 210 W, which comprises most of the AC-DC power supplies worldwide.	Accepted and text changed accordingly.
6	VI-12	Word changing on the first line - "(of the product families with EcoSmart technology, see above" The reason is the same as the cell above.	Accepted and text changed accordingly.
7	VII-11	Environmental impacts section. In the table, could the company be listed as Power Integrations, instead of PI. I don't believe that PI was used previously.	Accepted and text changed accordingly.
7	VII-11	Environmental impacts section (table). I believe the intent of this section to show what levels are currently achievable, Power Integrations has smps designs that easily comply with the CEC and ENERGY STAR active mode and no-load specs at both 3 W and 5 W. At the 5 W level, we have a reference design (DER-113) with a no-load of < 100mW and an average efficiency of 71.5%. At the 3 W level, we have a reference design (EPR-84) with a no-load of < 30 mW and an average efficiency of 61.5%. I think these examples should be used. They can both be found on our website at: www.powerint.com/appcircuits.htm	Accepted and the table modified accordingly.
7	7.1.1	I wish to point out that PanPower AB is not a manufacturer, we are just a R&D company and our policy is to keep our patented manufacturing method open to anyone who is interested to use it. This technology will be open to everyone.	Accepted and text modified accordingly.
7	7.1.11	Battery chargers: since in our discussion apparently the total est. qty is 16.000.000 only overnight chargers (what is the total est. qty than ??) which can have moderate to high energy losses (overnight chargers continue to charge permanently, so every hour after the battery is full is basically loss of energy…) Also there has been made a distinction between overnight chargers and microprocessor chargers, but what about	The text was indeed somewhat unclear and in addition there was a little mistake in the number. Text has been modified into: "For the total market of 14 million overnight and timer-controlled standard AA/AAA battery chargers sold annually…" Total quantity was given in task 2 (approx. 20 million)

		the middle segment: the timer chargers ?? Timer chargers at least limit the max. duration of energy taking and are from this point better than the standard – no control – overnight chargers, which still should represent a quite high share in the total demand.	
7	7.1.15	The fact that certain efficiency and no-load levels are achievable with existing technology does not mean that transitioning to a different EPS technology would be a low cost undertaking. You are clearly not considering, or maybe just unaware, of the re-design/re-certification costs at our level when going from one EPS model to another to be bundled with e.g. one printer or laptop model. These costs may range (estimate) from $100K to $150K per EPS and per supplier (we most often have at least 2 sources).	Such costs are related to the changes at the system level and they are not to be included in the Life Cycle Costs of a product (i.e. EPS/BC).
7	7.2.9	Option 6 (standardization of interfaces). While it is common for a given EPS to be shipped with 3 - 4 different printers the prospect of sharing an EPS between different product types with similar output power needs presents considerable challenges. Generally speaking, EPS's are designed to accommodate the power needs (power use profile) of the products they are intended to be used with: Safety/Reliability/Liability will be a huge issue here. Peak power requirements vary between products within the same output power range. Each product and solution (product and EPS) has a different EMC signature. Improper matching of EPS and product could result in lower efficiency.	The constraints and limitations of this option are outlined in section 7.1.12.
7	VII-53	Title of the Table should mention Cordless Power Tools (and not only Power Tools).	Accepted. Titles modified accordingly.
7	VII-53	Introduce the modified text: "The contribution of Cordless Power Tools chargers to the total energy losses evaluated in the context of this study represents less than 1.0 % of the total active and no-load losses of EPS and BC (Table 7-9: respectively 0.11 TWh over a total of 17.39 TWh for the total annual electricity consumption in use of the stock and 0.03 TWh over a total of 1.88 TWh for the No-load consumption of the stock per year)."	This kind of information will fit better at the conclusions of Task 5 and the conclusions there will be elaborated further. Task 7 conclusions deal with BAT and LLCC from the perspective of an individual product. To make this clear, a paragraph is added as the 2nd paragraph of the section 7.2.12: “The graphs allow conclusions only per product, not in the light of the overall stock of products from the scope of this study. See task 5 where a comparison of the stock per base case is provided for general significance of the different base cases.”
7	VII-53	Introduce the modified text: Chargers for cordless power tools have a potential for improvements evaluated between 10 to 15 % versus the base case but technical options to lower energy consumption in the different use modes (option 2) does not lead to lower life cycle costs which are slightly increasing. Theoretically only for the option of lifetime extension of the charger the consumer is likely to benefit from lower life cycle costs. Nevertheless, the major constraints of the lifetime extension option by standardization of connectors/interfaces/ batteries for cordless power tools chargers were specifically outlined in § 7.1.12.	Accepted. Text modified accordingly (maybe in slightly different words).

		Indeed, life cycle costs do not include costs of malfunction that may result from a misuse of the charger-battery system when selling cordless power tools without a charger adapted to the incorporated battery system.	
7	VII-53	Introduce the modified text: The option of standardization of chargers was already considered by the worldwide cordless power tools industry in early nineties but abandoned for major safety reasons. The increasing variety of chemical systems placed recently on the market reinforces the “safety” justification for not developing this option. It is one of the major reasons why standardization is developed within one product line by an individual manufacturer but not between manufacturers.	The first sentence is added with the reference (Stakeholder comment RECHARGE). Further text is somewhat obsolete as the work item proposal addresses this point explicitly: Same interfaces only for same battery chemistries (plus other parameters)
7		I already made the remark during the meeting that if the consumer behaviour is the most important factor in order to reduce the use of energy, this should be studied more deeply. If this is the case, it might be an option to use the technology we discussed in the meeting which can detect if an appliance is attached or not…….	It was not feasible to carry out a more detailed analysis on the real user behaviour (e.g. via extensive consumer surveys within this EuP preparatory study. As agreed in the final stakeholder meeting, consumer behaviour change is not a technical options and thus it could not be considered BAT/LLCC.
7		As far as I have understood the difference between the base case and improvement option 2 for EPS mainly are a change from linear mode to switch mode technology. Therefore I do not understand the increase in the production costs for implementing of option 2 while the base case already include switch mode technology (80 %).	Option 2 has rather to be seen as a "technology mix", which includes the change from linear to switch-mode, but also some improvements in switch mode technology itself. E.g. in the high power segment (laptops), the change from linear to switch mode is not an issue (100% switch mode today) - there it is rather switch mode improvements. We would have liked to be more precise and to identify a "delta" for each individual technical change, but there are too many parameters in electronics design, making such a dedicated analysis non-feasible. That's why we rather came up with this "technology mix approach", investigating what is available / feasible in terms of power consumption. Also the price increase has to be seen rather as a "mix": For the low power range it is mostly the change of the remaining linear products to switch mode (the competitive switch mode market in this segment also provides the higher efficiency switch mode PS - obviously no major price differences here), for the high power segment we had in
7		I think it would have been a better approach to have defined a base case only consisting of switch mode technology and not a mixture of linear and switch mode devices as the market is moving to that direction and that this technology already has a marked share of 80 %. Therefore I see no reason for inclusion of linear models in the base case.	We do not agree with the idea, not to take into account the linear ones in the base cases at all based on the reason, that they have 20% market share only. The base-case is intended to reflect the current market situation and those 20% are still on the market. There is clearly the market driven trend towards switch mode, but

			the linear ones are still out there and they are the "low hanging fruit".
7		Limitations of LLCC & BAT analysis should be more pronounced and heeded, or more sensitivity analysis.	Limitations are discussed in section 8, where sensitivity is also analysed.
8	8.1	It would be helpful to have an Appendix with all the values you used/assumed in the analysis. Now you mention only the growth rate and the average product life, and you assume a constant electricity price (but what price?). Other important variables seem the power consumption and the user profiles. Even if you take them from foregoing chapters, please put all input data together in an Appendix.	If not stated otherwise, the parameters for scenarios are those used for the base-cases. However, electricity price is added to the scenario introduction. But it does not seem meaningful to reproduce all the previous tasks in an Appendix.
8	8.1.1	Scenario 1: Improvements are not considered while constructing this scenario: A further reason for this is the interdependency of developments in various parts of the world. If Europe is not taking any action (the BaU scenario) then also other parts of the world might relax in pushing specifications.	True, as explained in the text "It should be noted that this is not a real-life scenario but rather a worst case. The products are likely to evolve even if EuP Directive implementing measures are not in place."
8	8.1.1	Scenario 2: What is the requirement exactly?	Minimum performance requirements corresponding to LLCC options identified in section 7.2.12. Cross-reference to this section added.
8	8.1.1	Tables and graphs of scenarios 2 and 3 There seem to be some inconsistencies between the tables and the graphs for scenarios 2 and 3: • electricity: the data for electricity is the same in scenario 2 and 3, whereas the data for total energy is different. • total consumer expenditure: in the tables total consumer expenditure for scenario 2 is higher than for scenario 3, but in the figure on page 5 it is the other way around.	True, there were inconsistencies due to an error which had occurred at the table editing phase. The figures in table have been corrected.
8	p. 5	Page 5 You indicate that you cannot correlate (?) reduced electricity costs to future product prices for scenario 3. But don't you have the same problem with scenario 2? The sentence "Furthermore, these expenditures calculations … in the coming years." is superfluous here, because you already mentioned in the introduction of the section that you assume constant electricity prices.	Text modified to clarify our message.
8	8.2	It is unclear from this section what exactly the policy or policies are that are considered and what the suggested levels are, and for which product categories they apply. E.g. on page 6 under the figure: "For the sake of harmonisation, CEC tier 2 requirements, …, appear relevant as short term targets." Do you mean that you propose to copy the CEC tier 2 requirements in an eco-design implementing measure? And what is short term? Does this refer somehow to the redesign cycles as discussed in Box 8-1?	Other parts of the world (California, USA, Australia/New Zealand, China, Korea) have made efforts to harmonise their performance requirements. As shown by the study, these requirements are reasonable also in Europe. Thus such levels seem like the most sensible option, at least as a first step (in short term).

8	8.2.1.1	EPS: 0.3 W and 0.5 W does not seem very innovative/challenging. Any efficiency requirements? Or is the figure on page 6 valid for all product categories? You mention margins of calculations. What does a technical analysis indicate? It seems clear that a technical analysis justifies the conclusion that on short term 0.3W is possible; the range in calculations results from uncertainties in costs etc. (i.e. non-technical aspects). On the medium term the no-load value should be 0.1 W thereby effectively eliminating the no-load problem.	No action. The purpose of the study is not to come up with challenges, but rather to help to define minimum performance limits. There is no robust data available on technical options to achieve 0.1 W WITHOUT having a contradictory effect on efficiency (as both have to be balanced thoroughly).
8	8.2.1.4	In item 8.2.1.4 in the 2nd sentence, it is proposed to write "Thus development of performance requirements for these products could be seen as the second priority."	Text modified into "Thus development of performance requirements for battery chargers have a lower priority than for EPS and halogen lighting transformers."
8	8.2.1.3	Why shouldn't the no load criteria not be in line with the criteria for EPS?	The on-mode efficiency threshold would eliminate magnetic transformers, and the electronic ones already achieve the no-load minimum values that seem reasonable for EPS.
8	8.2.2.2	I want to propose in 8.2.2.2 after the first sentence the following: Standardised interfaces are also a precondition to multiply the use of innovative BAT EPS, and to enhance the environmental and economic benefit of more efficient EPS.	Partially agree. Sentence added: "Standardised interfaces may also help to multiply the use of innovative EPS in the future."
8	8.3	The impact analysis is – compared to other parts of the report – superficial.	The aim here was not to carry out a comprehensive impact assessment, as the Commission will carrying out such an assessment separately on the proposed implementing measures.
8	8.3	Ban of certain basic technologies: "important market shares might be lost". You mean that an important part of the turnover of companies operating in those markets will be lost, because the market will disappear mostly or complete.	Yes, this is what is meant: the text slightly modified.
8		Open up all abbreviations.	Accepted, and abbreviations opened up when first mentioned and where considered to help the reader
8		Please use only one abbreviation for e.g. printed wiring board (PWB not PCB)	Accepted and text modified accordingly.
8		Eco profile (could be called as well eco declaration) should cover energy related issues and if needed references to existing regulations (chemical , product safety and environmental regulations e.g. in case of electronics - RoHS, REACH, Product Fire Safety)	Possibility added to section 8.2.2.1.
8		LCA results/figures should not be used in too detailed level - there are several types of methodologies which can give very different values/results	Very general comment. No action.
8		General/main comment: It is unclear from this chapter what exactly the policy or policies are that are considered and what the suggested levels (and other measures) are, and for which product categories they apply.	The purpose of this chapter is not to draft the implementing measure but rather to discuss the results of the study.

		Starting on page xi of Preface: I believe that the trademark ENERGY STAR should be capitalized every time it is used.	Accepted. Indeed capitalised name seems to be the official way to write it. Text in all the tasks changed accordingly.
		We should not forget that in the early years of DSC (5-6 years ago) 80% of the Digital Still Cameras was working on standard batteries and that many people will turn to rechargeables and chargers after a while. Still today according to GFK figures, in Germany and UK (where I have figures) around 40-45% of top selling quantities are working on standard batteries. This product group will therefore also largely influence the battery charger group.	True, the two different way to charge digital still cameras have been taken into account either in "digital camera EPS" or "standard battery chargers"
		Cordless phones, as discussed, it's clear that the base station is always connected and will always use some energy. (Consumer behaviour is leading to put the phone always in the station in order to recharge the batteries after each call – even if only few % of the energy is used)	We agree.
		If your estimation of overnight chargers in the market is more or less correct and the use is increasing due to more and more portable photo, audio and electro appliances, a market survey over the use of chargers would be interesting.	Indeed, unfortunately detailed market survey on this issue is out of scope of the Lot 7 study.
		Another interesting element is the newly launched low self discharge NIMH batteries (Panasonic Infinium / Uniross Hybrio / Ansmann Max e / Sanyo Eneloop / GP Recyko) : these batteries keep around 80% of the stored energy for up to 1 year and after 2 years still around 50% of the charged energy is still in them. If these batteries are used in combination with microprocessor chargers, the use of energy is limited to a minimum (if you charge your batteries again after 1 year storage, 80% of the charge is still there and the microprocessor controlled charger will notice this and only charge the missing 20%, which will lead to very short charging cycles and thus energy use.) Basically the wider spread of this technology could lead to major energy reduction in all categories where these batteries can be used either as single cells (Digital still camera, toys, audio equipment) as well as in packs for cordless power tools, cordless phones and other appliances which can work with combinations of NIMH batteries.	A paragraph on this issue is added to task 4.
		The remark in the draft report that switch technology is already dominant in the market is certainly the case for more the sophisticated products in Lot 7, but surely not for the battery chargers !	Accepted and a note added to task 2 (section 2.2.1.1)
		In all the work on EPS that I have seen, the focus has been on AC-DC EPS and it appears that AC-AC have been bundled in with the same performance requirements. I have been communicating with US EPA, California, ECOS and EU CoC on this matter. Two Australian companies have provided me with data which indicates that it is virtually impossible to have an AC-AC EPS above 40VA that will comply with the no load requirement.	The situation of AC-AC EPS is explicitly discussed in section 8.